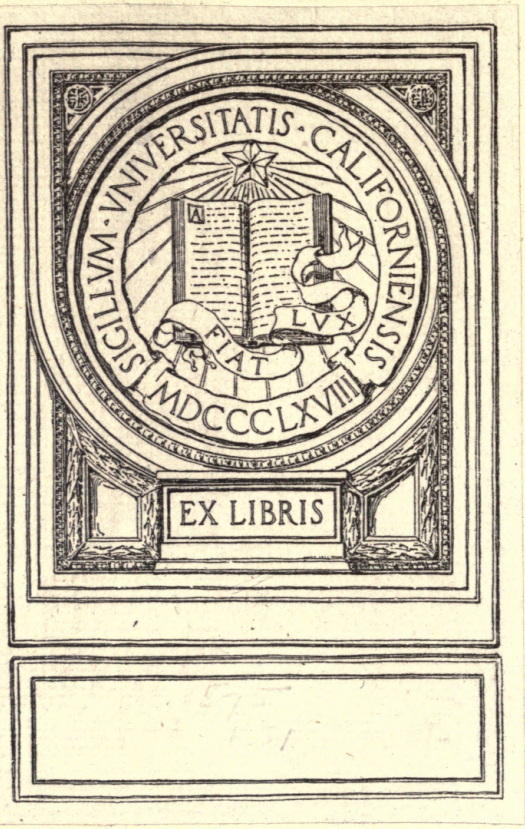
The Rolling Mill Industry

By F. H. Kindl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THE ROLLING MILL INDUSTRY

A Condensed, General Description of Iron and Steel Rolling Mills and their Products

BY

F. H. Kindl, *Engineer*
Pittsburgh, Pa.

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Preface

In this work the author has endeavored to give a condensed, general description of iron and steel rolling mills and their products, without discussing the details of rolling any special material. Essentially, it is a summary of American rolling mill practice, its development being traced from the beginning to the present day.

An effort has been made to define more closely the various mills and their products and the various classifications herein presented have been approved by leading manufacturers and many of the country's foremost iron and steel engineers.

The charts which graphically show the production of semi-finished and finished products, from 2,000 pounds of iron ore, 1000 pounds of coke and 600 pounds of limestone, represent modern practice at some of the largest open-hearth plants and rolling mills. Charts also are included to clearly illustrate the amounts of material charged and produced in making one ton of pig iron; the distribution and production of iron and steel in 1907 and 1911; the conversion of pig iron into the various finished products, etc.

For those interested in the economies of the iron industry, a table has been prepared in which a comparison has been made of the general fundamental factors dictating the production of pig iron in the United States, Germany and Great Britain, with particular reference to the Pittsburgh district of the United States, the Rheinland-Westfalia district of Germany, and the Cleveland district of Great Britain.

The author wishes to extend his thanks to the several companies and individuals who kindly furnished some of the necessary data for this work; to the United Engineering and Foundry Co., Pittsburgh, for the views of the various rolling mill installations and to the American and foreign iron and steel trade associations from which the statistics largely were obtained.

F. H. KINDL

Pittsburgh, June 2, 1913

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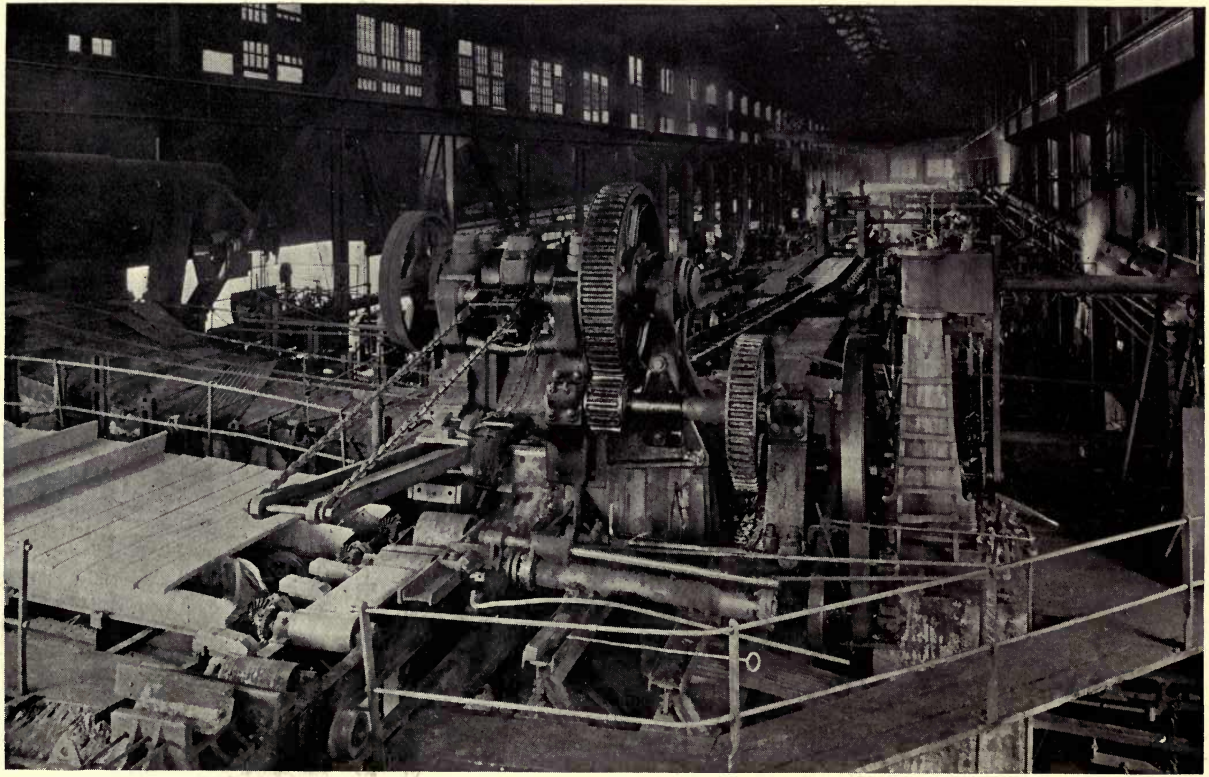

Fig. 1—Interior of Blooming Mill Building, American Tube & Stamping Co., Bridgeport, Conn.

THE ROLLING MILL INDUSTRY

Chapter I

Historical

WITHOUT discussing the details of rolling any special product, it must be of interest, at least to those engaged in the iron and steel business, to have a comprehensive knowledge pertaining to this important branch of the iron and steel industry, and with that in view, the writer will give a condensed general description of rolling mills and their products.

It will be conceded that the most valuable factor in the progress of the art of forming various sections from wrought iron and steel was the introduction of the rolling mill. Its development can be traced back to the time of Henry Cort, of England, who, in the latter part of the 18th Century, took out his patent for puddling, and mills with plain grooved rolls were first used for the manufacture of bar iron. These bars subsequently were welded and forged into various articles such as chains, hooks, etc., and were used largely for suspension bridges. In the course of development, the practicability of the plate mill was recognized, and the process of rolling wire became known, wrought

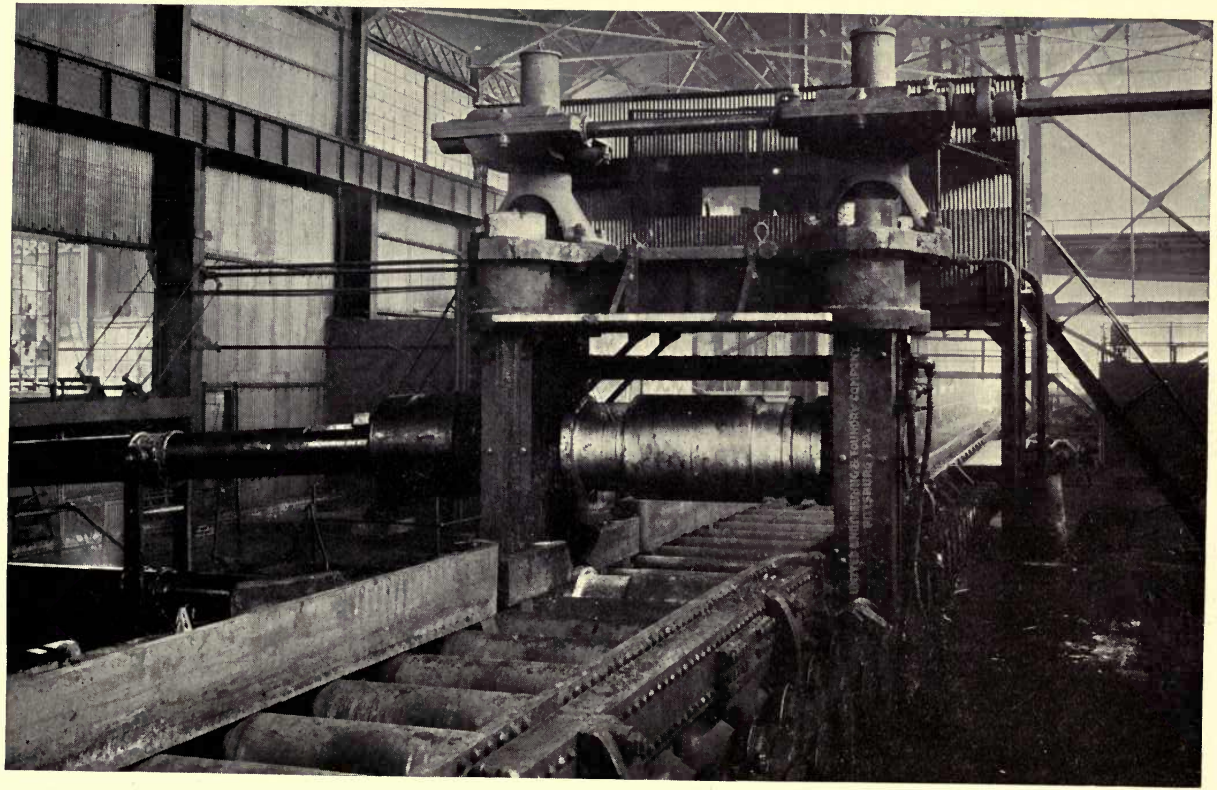

Fig. 2—40-inch Blooming Mill, Youngstown Sheet & Tube Co., Youngstown, O.

iron plates took the place of wooden planks for ship construction, plate iron boilers were substituted for cast iron boilers, and wire cables displaced chains in suspension bridges.

The First Plate Mill

In 1780, the first plate mill was built at Neuwind, Germany, and in 1820, John Berkinshaw, of Belington, Eng., rolled the first practical rail, although angles and T-iron were rolled at an earlier date.

As the process of rolling plates became better known, the plate box-girder and lattice-girder were introduced, and wrought iron bridges began to replace those built of cast iron and wood. Concurrent with the growing requirements for wrought compression members in bridges (introduced in the United States first), came the demand for suitable structural shapes. Thus we might credit England with having rolled the first rails, angles, T and Z-shapes; Germany with rolling the first plates; France with designing and rolling the first I-beams and channels, and the United States with designing and rolling the first segmental shapes so much found in the older designs of built columns. The use of wrought iron shapes for compression as well as tension members in connection with plates caused a more general distribution of their use for other constructions than bridges, such as cars, ships, buildings, etc., until today, with the exception that the material is no longer wrought iron, but steel, rolled structural shapes and plates form the very skeleton of all our modern structures.

American Supremacy

While the supremacy of the United States in the iron and steel trade is generally recognized, there is no other branch of the iron and steel industry, perhaps, in which the United States has more reason to take pride than this, for on no other have we stamped our national individuality so deeply. The American bridge, the American steel skeleton building, the American rail, the American wire, and the American steel

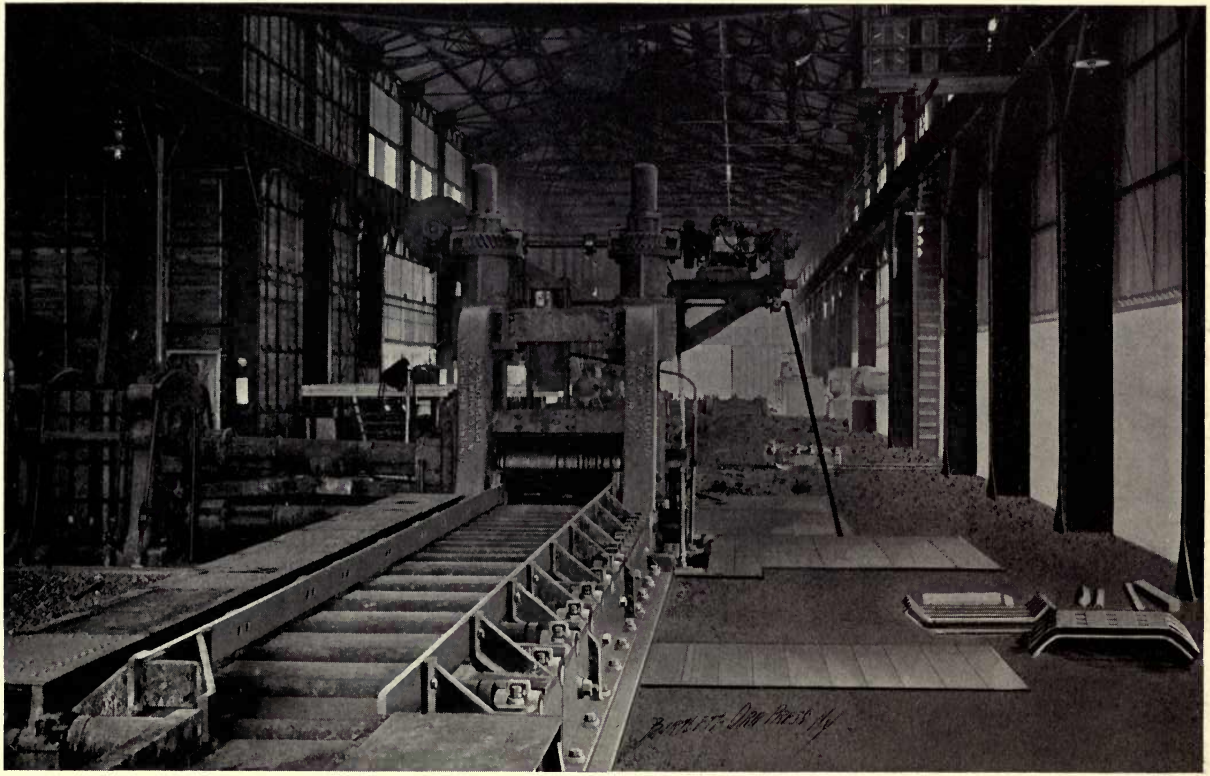

Fig. 3—34-inch Blooming Mill and Tables, Andrews Steel Co., Newport, Ky.

car are those forms of construction that are recognized the world over as having received their most marked development in this country and are a direct result of the American rolling mill industry. Although the fundamental features of the supremacy of the United States in the iron and steel industry are to be found in the marvelous resources of our country, too much cannot be said in praise of the intelligence and skill with which the American iron master has risen to his opportunities. It is to the remarkable ingenuity shown in the production of labor-saving machinery that much of the low cost of production is due, to say nothing of the broad administrative ability shown by the management of the great steel works in laying out the component parts of their establishments in such a manner that the heavy tonnage which passes through these plants, day after day, shall proceed from the ore to the finished product with the minimum amount of handling and trans-shipment. Finally, the more prominent iron and steel men, early in the history of the development of the industry, perceived and acted upon the fundamental economic principle that for cheap production of iron and steel, large operations and combinations of capital are essential.

Labor-Saving Equipment

The ingenuity and resourcefulness displayed in handling and transporting the large tonnage of raw material, such as ore, coal, coke, etc., required in the production of a constantly increasing tonnage of rolled material, was ably followed when it came to the recovery of the iron in the blast furnaces and the subsequent conversion into steel and its fabrication into the thousand forms in which the finished material is offered for sale upon the market. In no single branch of any industry has more thought been given to labor-saving devices than in the manufacture of iron and steel. First, to reduce the handling and trans-shipment to a minimum, the processes are made as continuous as possible. The erection of a modern, typical steel works calls for a plot of ground preferably parallelogram in shape, and many plants can

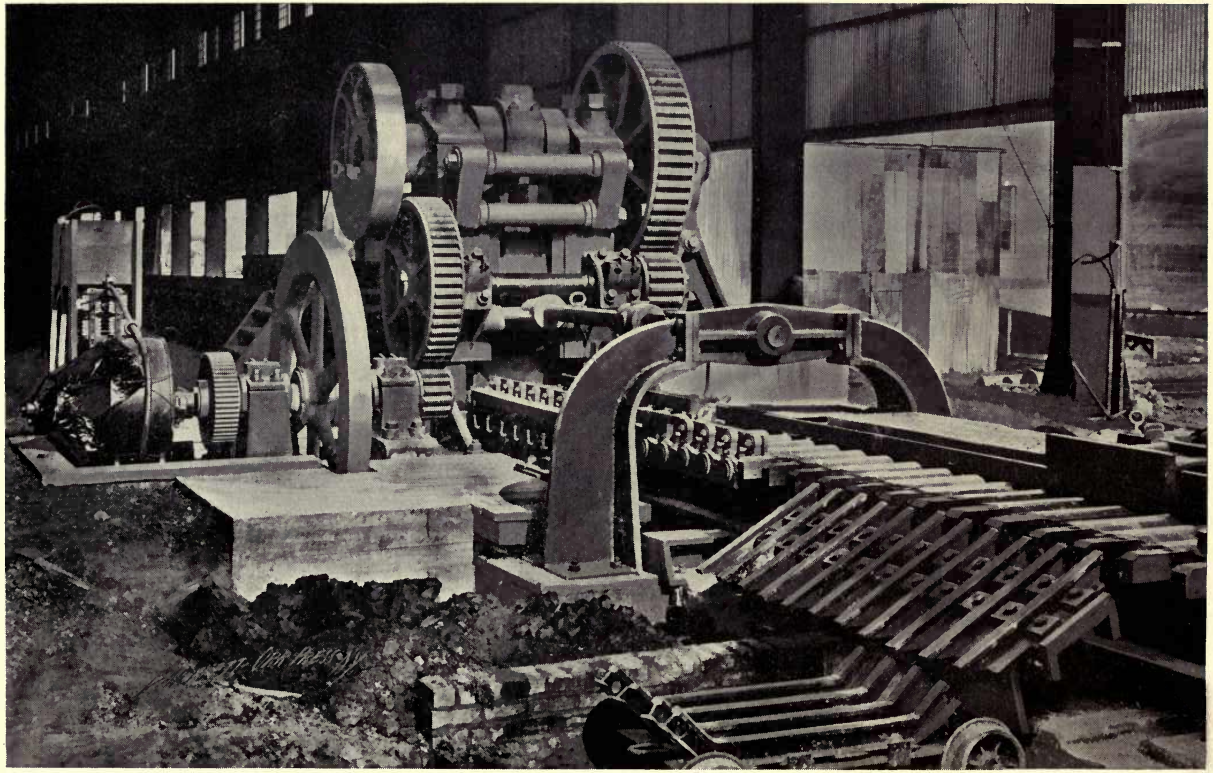

Fig. 4—Bloom Shear and Tables, Andrews Steel Co., Newport, Ky.

be found today occupying land having a width of one-half mile by more than a mile in length, along the borders of a navigable stream or lake, from which the necessary supply of water is derived and the transportation by water made possible.

At one end of a typical steel plant are located the blast furnaces with their artificial mountains of ore, coke and limestone; then the mixer, followed by the Bessemer or open-hearth furnaces; next in line is the ingot-stripper building with its adjoining soaking pits or furnaces for heating the cast ingots. Directly connected with these, stretch enormous buildings, 1,000 feet or more in length, with their blooming, cogging and slabbing mills, followed directly by the various finishing mills, shears, transfers, hot beds, saws and straightening departments, succeeding each other in progressive order up to the stock yard and shipping department, from which the finished product is loaded upon cars almost before the last trace of furnace heat has left it.

Furthermore, in its transit through the mills, the material has been rolled and heated and rerolled without the use of manual labor, and for many forms of material, the continuous processes are carried on with such rapidity that the entire rolling from the ingot to the finished shape is accomplished in a single heat.

Electrical Age in Steel Plants

In summing up the causes of the success in the manufacture of steel, great importance must be given to the early varied application of electricity as a motive power in the thousand uses to which it has lent itself so admirably. This valuable accessory to our steel works practice was formerly generated entirely from coal-fired boilers and steam engines connected to electric generators, but today it is derived from the by-product of the blast furnace which supplies the necessary gas for heating the boilers and generating high pressure steam to be used in turbines direct-connected to electric generators, or is directly converted into power by means of gas engines connected to electric generators. Large buildings in which thousands of kilowatts of electricity are thus

generated hourly and known as central power plants, are indispensable to the modern steel works.

Applications of Electricity

Among the most useful applications of the electric current in iron and steel plants are the electric skip-hoist for charging the blast furnace; the electrically-operated bridges spanning the stock yard of the blast furnace department; the overhead electric traveling cranes, covering in their range the entire length of both charging and pouring sides of the open-hearth furnaces and entire mill buildings; the electric charging machine that picks up a box containing a ton or more of mixture, which is thrust into the furnace, emptied and withdrawn therefrom; electric strippers which strip the ingot mold from the cast ingot; electric soaking pit cranes for depositing the ingots in the heating furnaces and withdrawing them; electric buggies that receive the heated ingot after it has been lifted from the soaking pits and run it to the rolls; electric pushers for pushing the blooms into the furnace to be reheated, and electric tongs for gripping the blooms and pulling them out at the other end; electric motors for driving the rolling mills; electric traveling tables on either side of the mills for conveying the material to be rolled to the various passes of the rolls and to receive it after passing through the rolls for transfer to the hot beds, which also are electrically-operated.

These are a few of the uses of electricity in the steel works without mentioning its many applications to other operations in the mines, railroad and ship transportation, and its direct use in the conversion of iron to steel, where, with ingenuity, forethought and administrative skill, it has enabled the American manufacturer to compete with the world, while paying the highest wages to labor and returning immense dividends on capital invested.

Chapter II

Classification of Rolling Mills

THE production of rolled forms of iron and steel is accomplished in rolling mills. A rolling mill consists of a train of rolls, which in turn is composed of roll stands; each stand consists of at least two rolls set between and carried by frames called housings.

The rolls are cast iron or steel cylinders with their axes set parallel and horizontally above each other, and held in the housings so that a fixed space is left between the surfaces of the rolls. The rolls are driven by electric motors or steam engines, through gear transmission, in such a manner that they rotate in opposite directions; the gears are connected to the motive power and rolls by means of spindles, or short shafts and coupling boxes.

The operation of rolling consists in passing between the rolls a tough and pliable material, such as heated steel, having greater thickness than the space between the rolls, the result of which is a compression and reduction of cross-section of the material and its consequent elongation.

The process is similar to that used by the blacksmith in the elongation of a piece of hot steel by means of the hammer, except that the same result is accomplished much more rapidly on account of the continuity of work by means of rolling.

Iron or steel is either rolled direct from its initial heat or is reheated in furnaces suitable for this purpose, to such a temper-

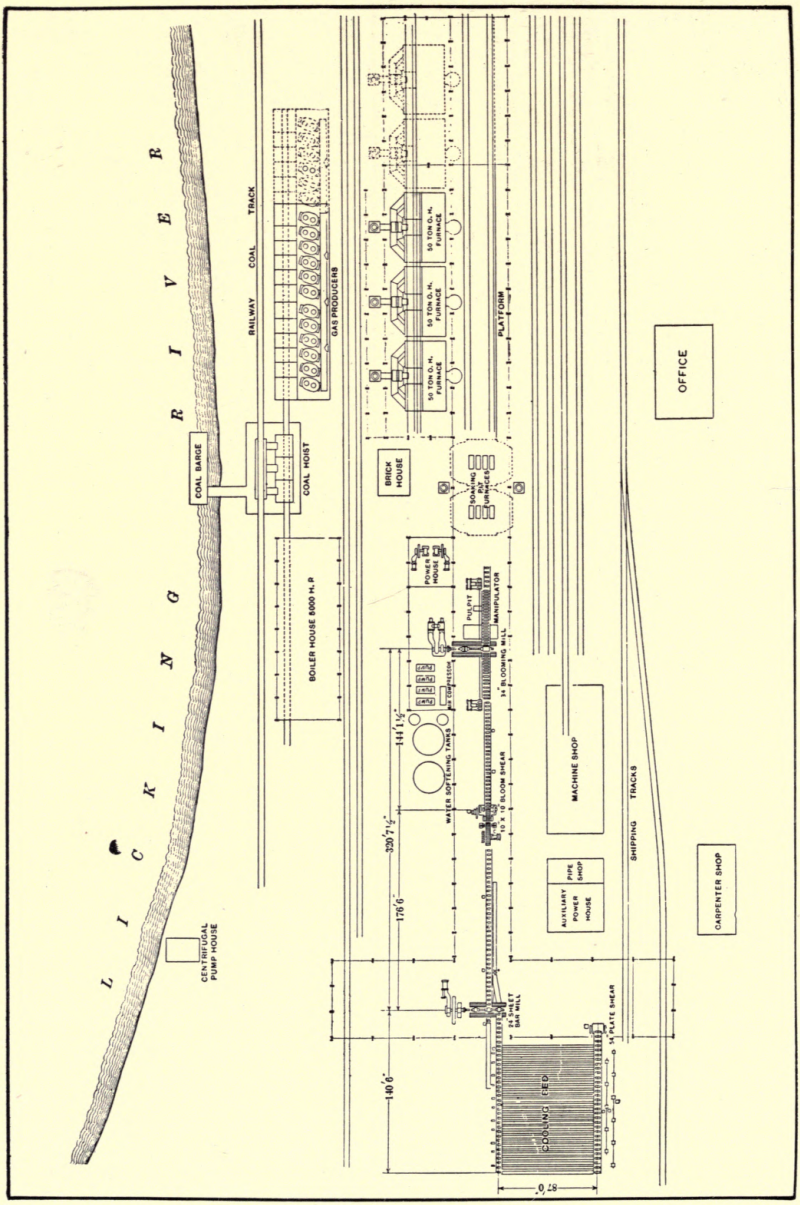

Fig. 5—Blooming and Sheet Bar Mill, Andrews Steel Co., Newport, Ky.
This Mill Consists of one stand of 34-inch Blooming Mill Rolls and two stands of 24-inch Bar Mill Rolls, together with Tables, Transfers, Cooling Beds, Shears, etc.

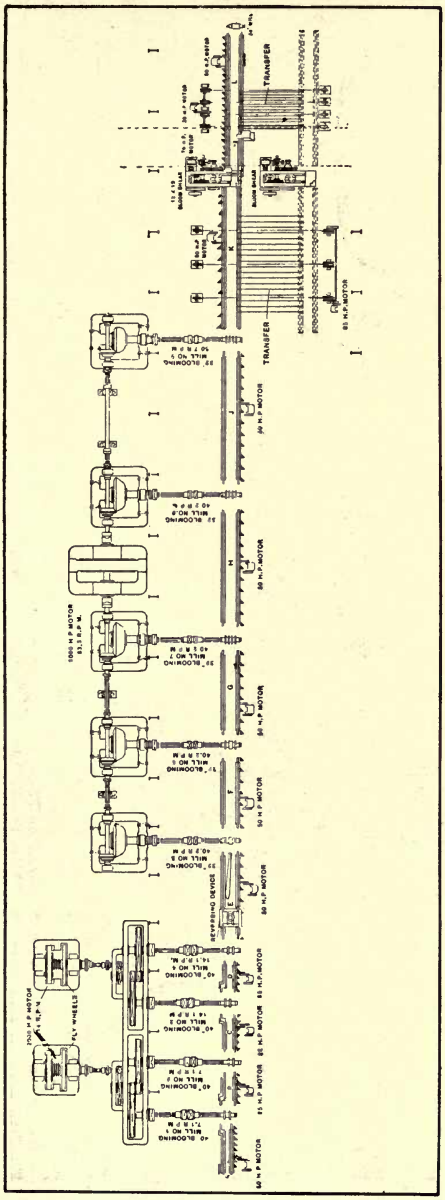

Fig. 6—Motor-Driven Continuous Billet Mill at the Plant of the Indiana Steel Co., Gary, Ind.
This Mill Consists of four, two-high stands of 40 inch Rolls and five two-high Stands of 32-inch Rolls, with Tables, Transfers, Shears, etc.

ature as to soften and render it pliable. Notwithstanding its soft condition, the resistance to change of form is considerable and requires numerous passes of the material through the rolls before the desired final shape is obtained.

Classes of Rolling Mills

Rolling mills can be divided into two fundamental classes, namely, reversing and non-reversing mills. The reversing mill, types of which are shown in Figs. 2 and 3, has two rolls, one above the other, or two-high, which are stopped after each pass; the engine then is reversed and the material is passed through the rolls in the opposite direction. Owing to the impossibility of using a fly-wheel, stored

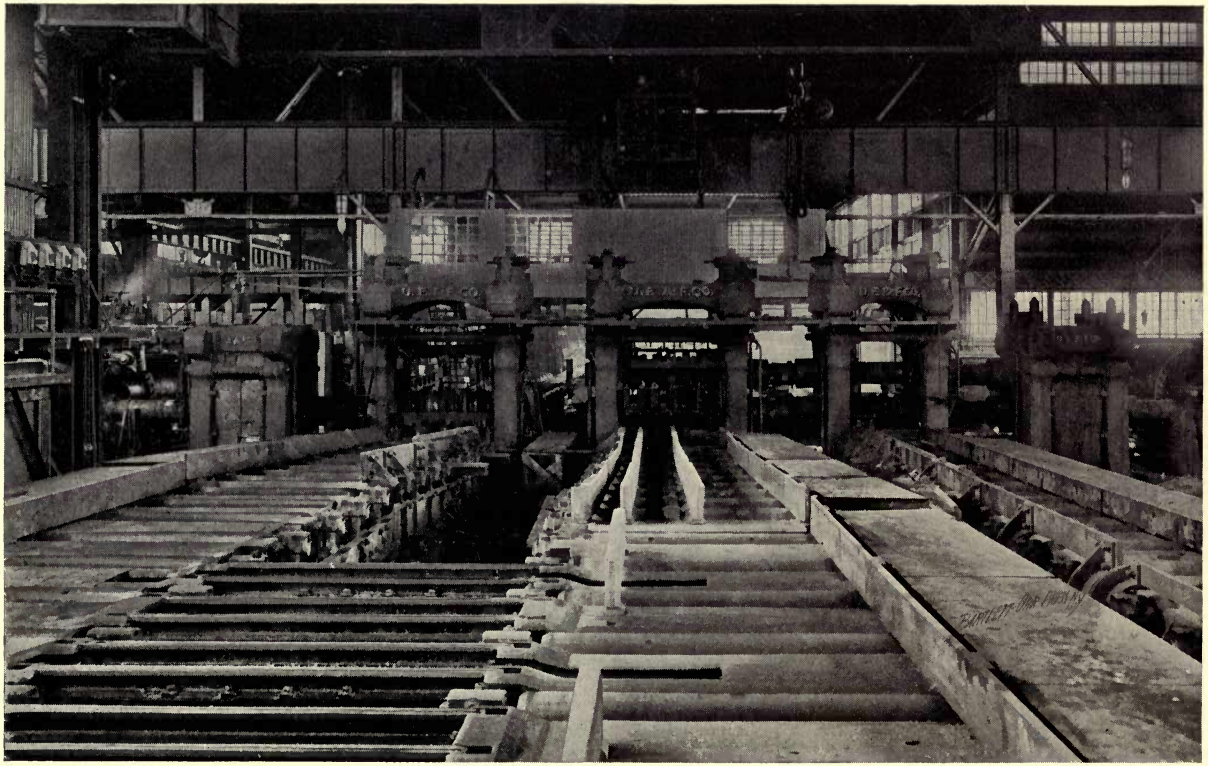

Fig. 7—28-inch Rail Mill and Tables, Bethlehem Steel Co., South Bethlehem, Pa.

energy to equalize overloads cannot be used and the engines of such mills must be exceedingly heavy and powerful, making such installations very expensive, and generally restricting them to mills rolling heavy ingots, difficult to raise and handle.

The non-reversing or continuous running mill, types of which are illustrated in Figs. 7, 23, 25 and 26, consists of three rolls, one above the other, or three-high, in which the piece passes between the lower and middle rolls in one direction and between the top and middle in the return pass. It is self-evident that this arrangement is the more productive, as the rotation of the rolls is not interrupted and thus the use of a heavy fly-wheel is not excluded.

Rolling mills are generally distinguished by the name of the product which they are designed to roll. They may be referred to by their size, or rating, which, for everything except plates, is based upon the diameter of the rolls; in the case of plates, the maximum width which can be rolled fixes the size of the mill.

They may be named with reference to the arrangement of the individual stands to each other, also with reference to the kind of material rolled, such as steel, tool steel, copper, lead, brass, etc.

Classification of Rolling Mills

Mills classified in accordance with the name of the product which they roll, follow:

1.—Blooming, cogging and slabbing mills, being the preparatory mills to rolling finished rails, shapes or plates, respectively. If reversing, they are from 34 to 48 inches in diameter, and if three-high, from 28 to 42 inches in diameter. Blooming mills are shown in Figs. 2 and 3, and a universal plate mill is illustrated in Fig. 21. A plan view of a blooming and sheet bar mill is shown in Fig. 5.

2.—Billet mills, three-high, rolls from 24 to 32 inches in diameter, used for the further reduction of blooms down to 1½ x 1½-inch billets, being the preparatory mills for the bar and rod

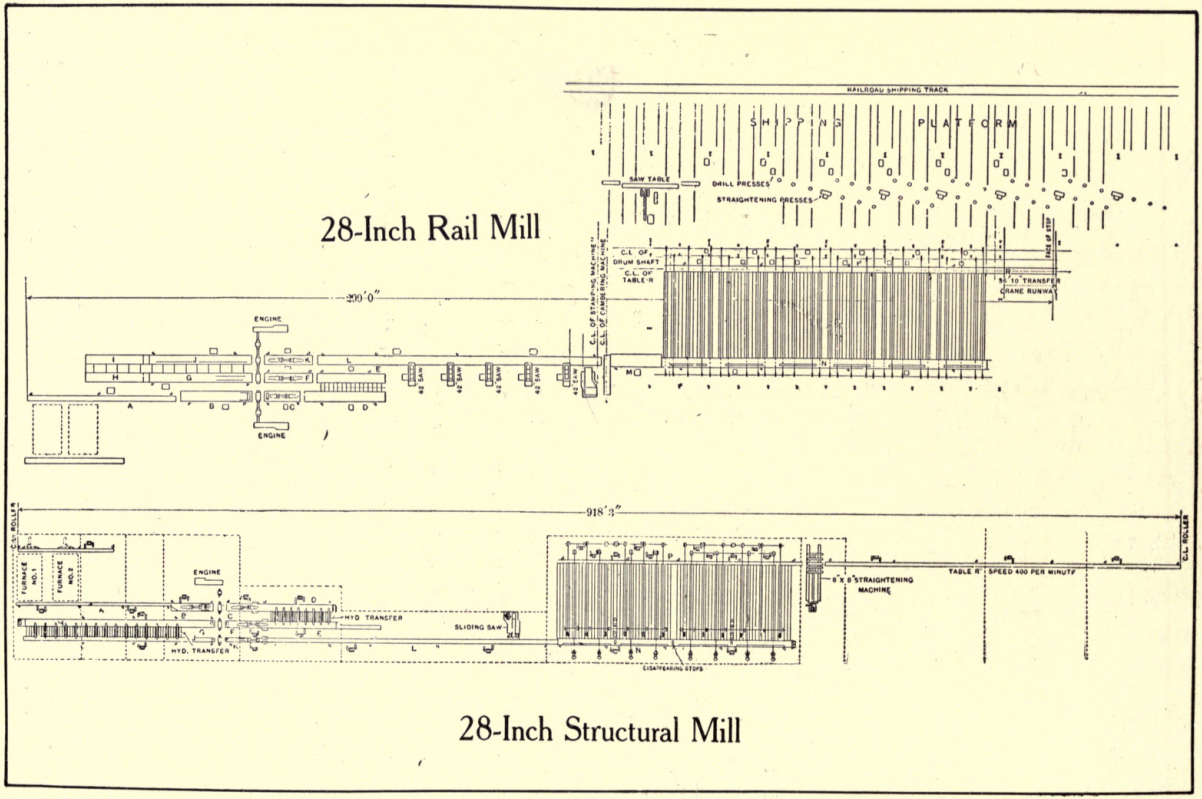

Fig. 8—28-inch Rail Mill and 28-inch Structural Mill, Bethlehem Steel Co., South Bethlehem, Pa.
Each Mill Consists of three stands of 28-inch Rolls with Stationary and Tilting Tables, Transfers, Hot Beds, Saws, Straightening Machines, Presses, etc

Classification of Rolling Mills

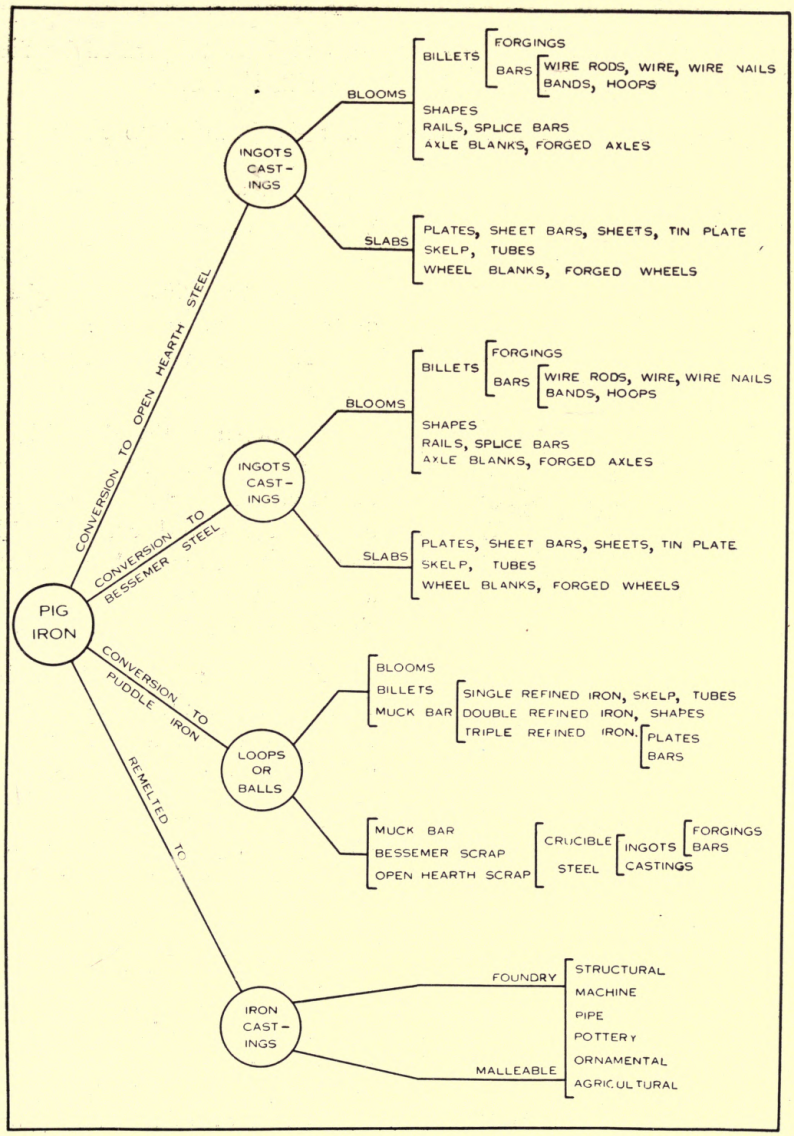

Fig. 9—Chart which Graphically shows the Conversion of Pig Iron into Ingots, Castings, Etc., and the subsequent finished products.

mills. A plan view of the continuous billet mill operated by the Indiana Steel Co., Gary, Ind., is shown in Fig. 6.

3.—Sheet bar mills, three-high, rolls from 24 to 32 inches in diameter, used for the further reduction of slabs and blooms to sheet bars; these are the preparatory mills for sheet and tin mills. Sheet bar mills are shown in Figs. 22 and 23, and a plan of mill, Fig. 5.

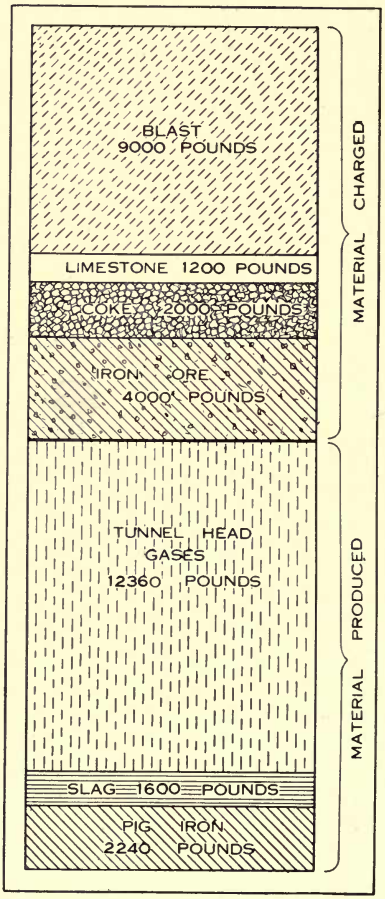

Fig. 10—Amounts of Material Charged and Produced in Making one Ton of Pig Iron

This Represents American Blast Furnace Practice in the Northern District.

4.—Beam mills, three-high, rolls from 28 to 36 inches in diameter, for the production of heavy beams and channels 12 inches and over. A plan of a 28-inch structural mill is shown in Fig. 8.

5.—Rail mills with rolls from 26 to 40 inches in diameter. A plan for a 28-inch rail mill is shown in Fig. 8.

6.—Shape mills with rolls from 20 to 26 inches in diameter, for smaller sizes of beams and channels and other structural shapes. A mill for this work is illustrated in Fig. 25.

7.—Merchant bar mills with rolls from 16 to 20 inches in diameter. Types of these mills are shown in Figs, 25, 26 and 27.

Classification of Rolling Mills

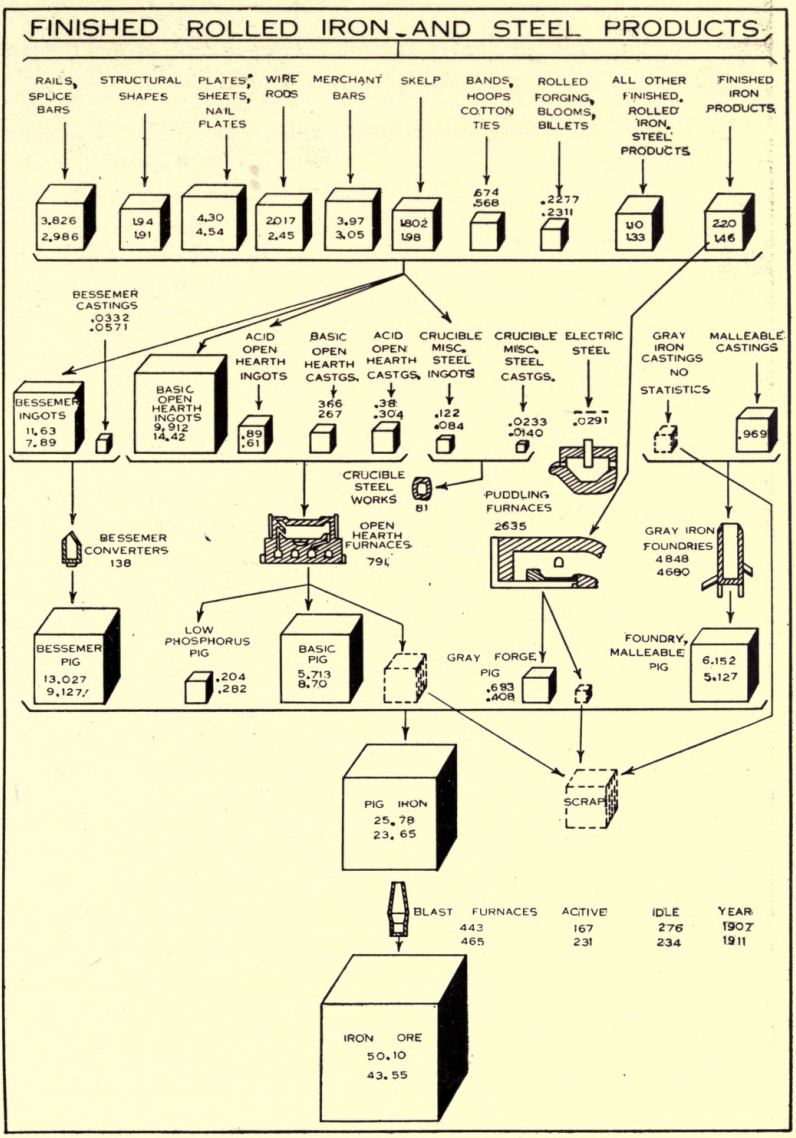

Fig. 11—Production Conversion Chart for the Years 1907 and 1911. Production in millions of tons

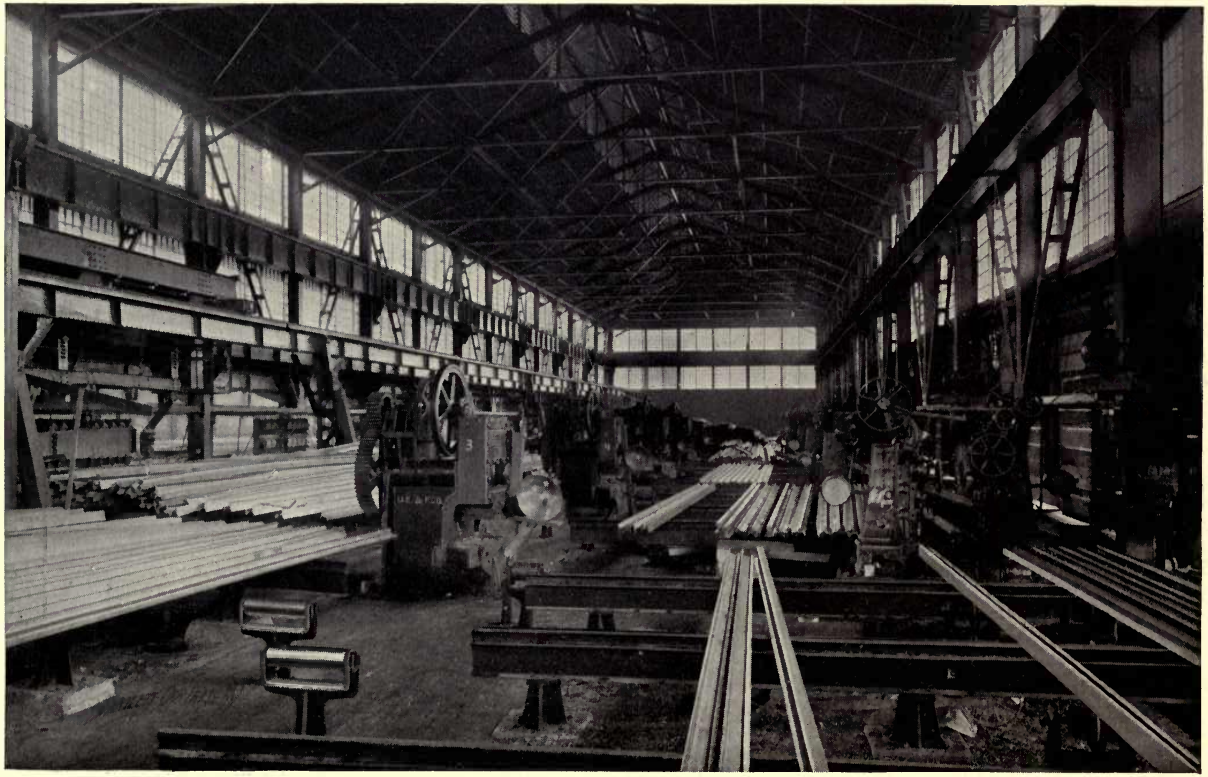

Fig. 12—Rail Mill Finishing Department, Bethlehem Steel Co., South Bethlehem, Pa.

8.—Small merchant bar mills with finishing rolls from 8 to 16 inches in diameter, generally arranged with a larger size roughing stand. Such a mill is shown in Fig. 27.

9.—Rod and wire mills with finishing rolls from 8 to 12 inches in diameter, always arranged with larger size roughing stands, Fig. 24.

10.—Hoop and cotton tie mills, similar to small merchant bar mills, Fig. 27.

11.—Armor plate mills with rolls from 44 to 50 inches in diameter and 140 to 180-inch body.

12.—Plate mills with rolls from 28 to 44 inches in diameter, Figs. 19 and 20.

13.—Sheet mills with rolls from 20 to 32 inches in diameter.

14.—Universal mills for the production of square-edged or so-called universal plates and various wide flanged shapes by a system of vertical and horizontal rolls, Fig. 21.

15.—Tube mills for the production of tubes.

16.—Special mills, such as slitting, piercing, tire wheel mills, etc.

17.—Cold mills.

Mills in classifications Nos. 1 to 10, inclusive, have grooved rolls.

Mills in classifications Nos. 2, 3, 9, 10, 13 and 15, for large tonnage production, are preferably built of the continuous type, which consists of a number of stands of two-high, non-reversing rolls, one behind the other, which are driven at progressively increasing speeds. A plan of a continuous billet mill is illustrated in Fig. 6, and Fig. 24 is a Morgan continuous mill.

Rolling Mill Layout

The general layout of a rolling mill is dependent upon many conditions, but it will be found here, as in all up-to-date manufacturing establishments, that the arrangement is such as

to provide for a logical, continuous, progressive and economical operation, so that the material to be rolled enters at one end of the mill and leaves it as a finished product at the other end. Ample space is provided so there may be no overcrowding, and provisions are made on all mills to roll the greatest possible finished length in one heat. The arrangement of various types of mills is shown in Figs. 5, 6 and 8.

The progressive steps in a complete plant to convert the ore into the finished product are as follows: From the blast furnace to the mixer, to the steel works, to the soaking pits, to the blooming, cogging or slabbing mills, to the various finishing mills, to the hot beds, through the saw and straightening departments to the shipping yards. The conversion charts, Figs. 9, 11, 13 and 14, graphically illustrate the conversion of ore to the finished products.

Semi-Finished Products

The products of a rolling mill are divided into semi-finished and finished rolled material. To the first belong rolled blooms, slabs, billets and sheet bars. This material is produced by rolling an ingot to square, rhomboidal or flat sections having more or less rounded corners. When an ingot has been reduced to a section 6 inches square or larger, it is called a bloom; if rolled flat to a section having a thickness not less than 2 inches and a width of at least 12 inches, it is called a slab; if from 1½ inches square or round and less than 6 inches square or round and cut into lengths, it is called a billet. A sheet bar is a section having a thickness less than 2 inches and a width from 6 to 12 inches.

Semi-finished material is commercial only as such, and not being straightened or cut square on the ends, it is only adapted for use for further rolling or working into more highly finished products.

Chapter III

Finished Products

THE finished rolled material includes all iron and steel rolled to finished forms. It is the product or forms produced by rolling semi-finished material in finishing mills. This class may be divided into the following groups:

First.—Bars, rods, wire rods, bands and hoops, Fig. 13.

Second.—Shapes, structural shapes, rails and splice bars, Fig. 13.

Third.—Plates, sheets, skelp and nail plates, Fig. 14.

Fourth.—Forgings, armor plate, axles, wheels, tires and drop forgings, Fig. 14.

First Group

Bars, rods, wire rods, bands and hoops, constituting the first group, are produced from blooms, slabs and billets by reducing this material to the simplest forms, such as squares, rounds and flats. These forms resemble the cross-section of the material from which they are rolled, and their final section determines their nomenclature. The materials of this group have great length compared with their width and thickness. The steel from which they are rolled is prepared to conform to certain specifications, and the section must be within certain limits as to size and weight, and must be suitable for further fabrication into bolts, nuts, spikes, chains, rivets, wire, wire nails, hoops, cotton ties,

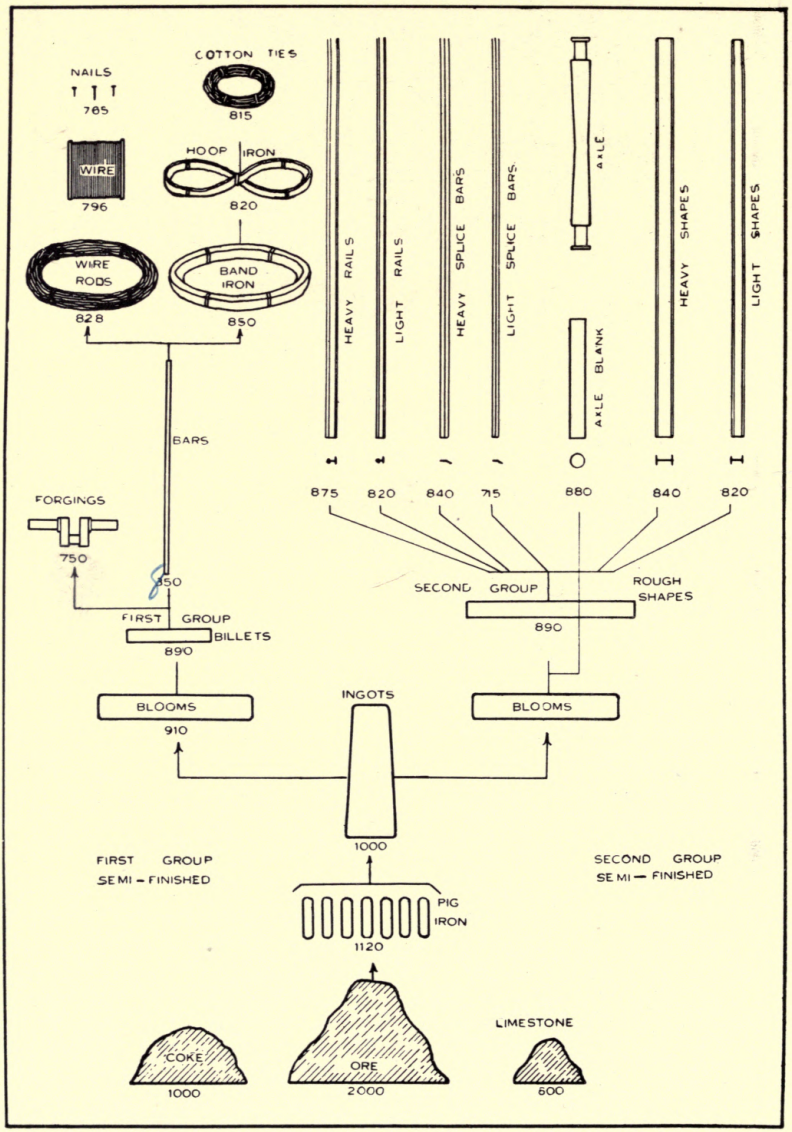

Fig. 13—Production Conversion Chart showing the Weight in Pounds of Open-Hearth Steel Products Obtained from 2,000 Pounds of Ore.

Finished Products

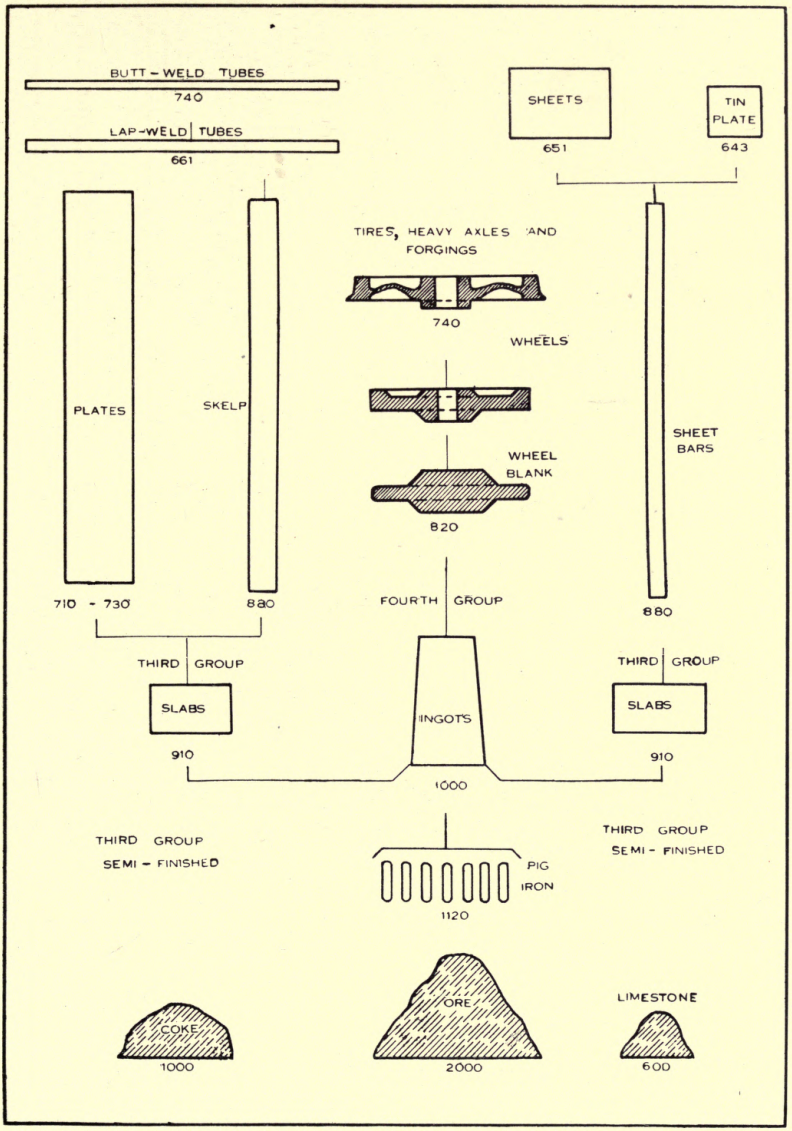

Fig. 14—Production Conversion Chart showing the Weight in Pounds of Open-Hearth Steel Products Obtained from 2,000 Pounds of Ore.

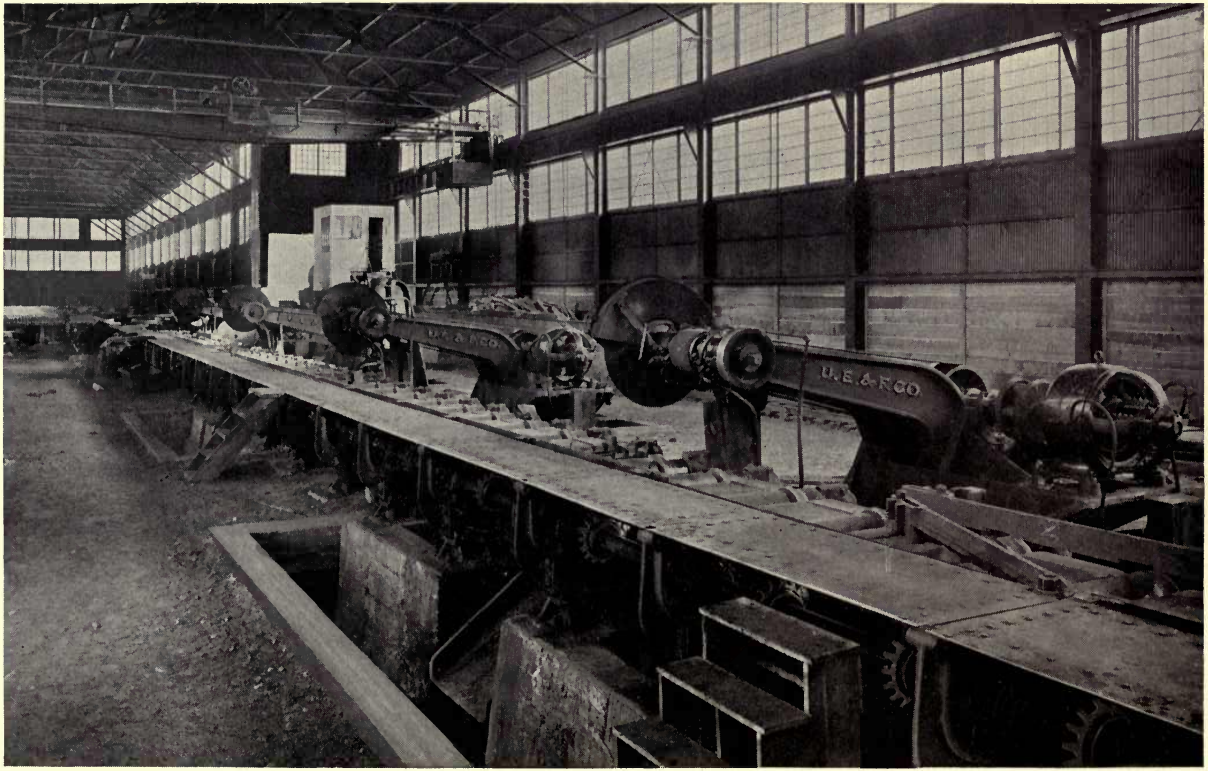

Fig. 15—Tilting Frame Hot Saws for Rail Mill

springs, etc. Bars may be either square, round or flat; the sizes to which they are commercially rolled being 3/16 to 7¼ inches square or round. Sizes ¾ to 3 1/16 inches are known as base or standard. Flats are commercially rolled ⅜ inch wide by ⅛ inch thick up to 6 x 4 inches; sizes ⅜ x ⅛ inch to 6 x 3/16 inch are classed as light bars and bands, and sizes 1 x ⅜ inch up to 6 x 4 inches are commercially classed as flat bars and heavy bands. Sizes from 1 to 6 inches wide x ⅜ inch to 1 inch thick are known as base or standard.

A rod is generally understood to be a round bar. Standard wire rods are round bars having a section 0.2 to 0.3 inch in diameter, which are coiled in bundles. The United States government limits the size of wire rods to No. 6 B. W. G., or 0.203 inch, and if thinner than this, the product is termed wire.

Hoops are very thin flats having a thickness from No. 13 B. W. G. to No. 23 B. W. G., and from ⅜ to 8 inches in width. Owing to their general length, they are coiled the same as wire rods, but are subsequently annealed, cut to length and shipped in bundles.

Cotton ties is a product made from hoop iron or steel cut to certain lengths and used for fastening bales of cotton. They are generally shipped in bundles, each containing 30 ties and weighing 45 pounds per bundle.

Second Group

Shapes, constituting the second group, are reduced from blooms, slabs or billets to forms having more or less irregular section. In the process of rolling, the original material is not only reduced in section, but it is also developed into a definite shape. The various shapes are given commercial names, such as rails, splice bars, I-beams, channels, zees, tees, angles, etc. The heavier and larger sizes of these shapes are frequently rolled direct in one heat from the ingot to the finished material.

After leaving the rolling mill, shapes are cut to length and are cooled on cooling beds, shown in plan in Fig. 7. Fig.

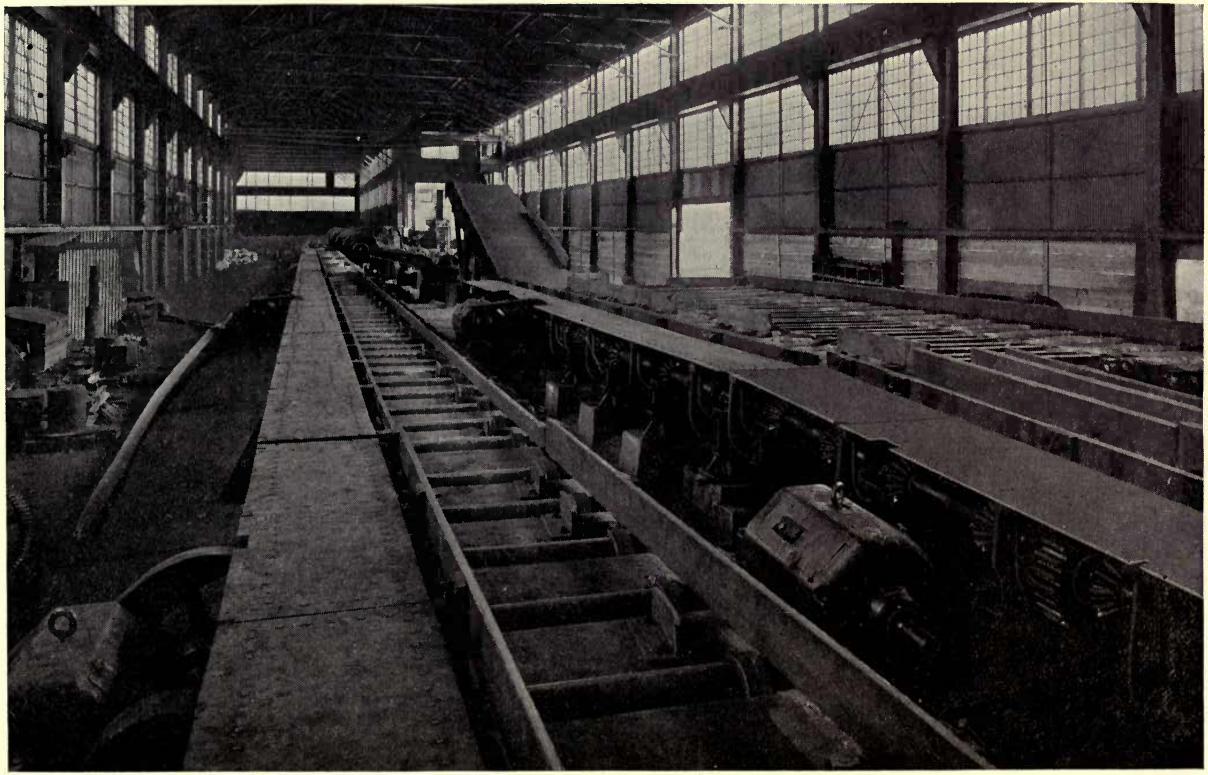

Fig. 16—Hot Saw Run for Rail Mill

17 is a rail mill cooling bed. The shapes are subsequently straightened by means of straightening rolls or presses, the latter work being performed in suitable shops adjoining the rolling mill, and in this condition they are known commercially as structural shapes. These shapes are further developed and worked into various products at shops specially adapted to carry out the character of the work for which they are intended. For example, the fabrication of products built for building construction is carried on in architectural iron works; bridges at bridge works; ships at ship yards, and railroad construction at car shops.

The steel from which structural shapes are rolled is prepared to conform to three kinds of specifications, namely, for buildings, bridges and ships.

Rails

Rails are rolled shapes used for guiding and carrying the wheels of railroad cars, and are produced in rolling mills specially designed for this purpose and known as rail mills. A plan view of a rail mill is shown in Fig. 8, and the various rail mill departments are illustrated in Figs. 7, 12, 15, 16, 17 and 18. The steel from which rails are rolled is prepared to conform with standard specifications for steel rails, and the sections of rails in the United States are largely made in accordance with the American Society of Civil Engineers' standards. Rails are divided into light and heavy rails, light rails being those weighing less than 40 pounds per lineal yard. Rails, in addition to being sawed square and straightened, are drilled at their ends for holes to receive the bolts used for splicing or joining the ends of two rails. While rails are rolled to 120 feet and more, the standard length when shipped is 30 to 33 feet.

Splice bars are rolled shapes used for joining the ends of rails. They are cut accurately to length and must fit perfectly to the rails for which they are intended. They are punched to match the holes drilled in the rails as well as notched to receive the spikes fastening them to the wooden ties.

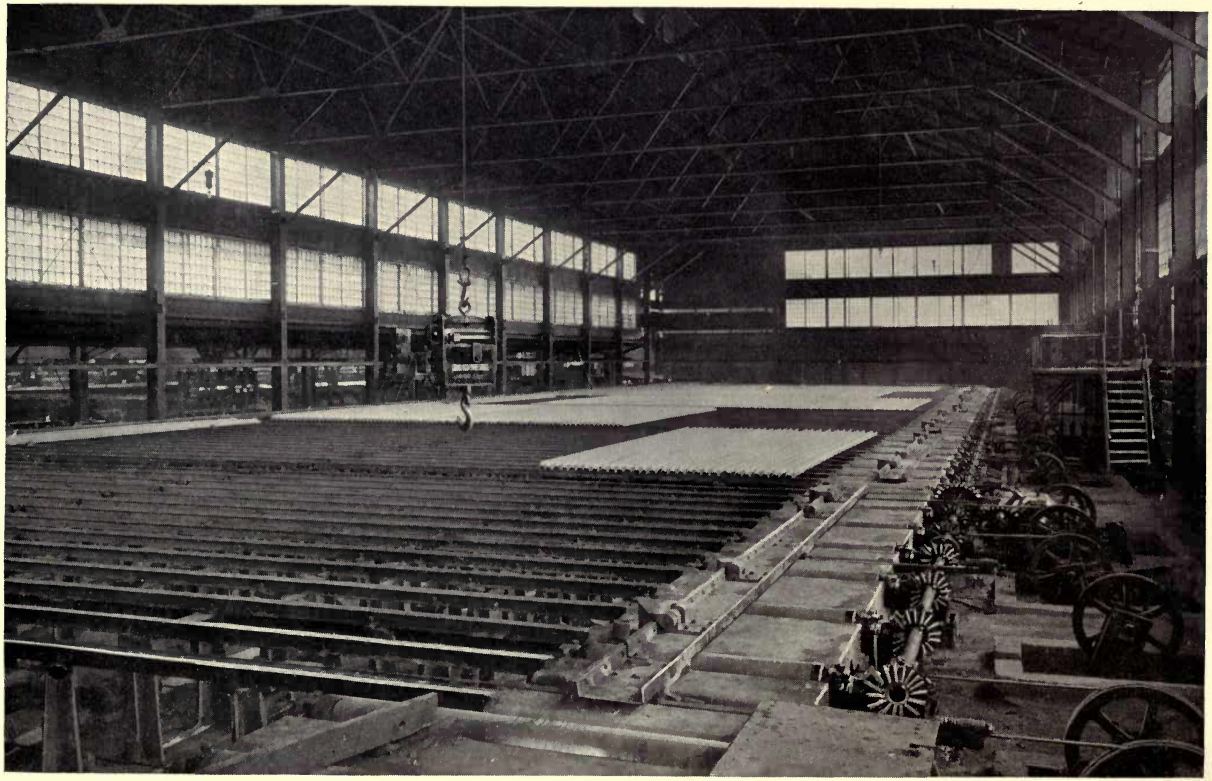

Fig. 17—Hot Bed for Rail Mill

Third Group

Plates and skelp, of the third group, is the material obtained by rolling slabs and blooms in mills known as plate and skelp mills, respectively, shown in Figs. 19 and 20. A sheet is the product obtained by rolling sheet bars in sheet mills. While bars and shapes have great length compared with their other dimensions, this does not apply to plates and sheets where the width is also well developed; this form of product is known as sheets when rolled to a thickness less than No. 12 gage. The United States government limits this thickness to No. 10, United States standard gage. With reference to quality and use, plates may be divided into tank, bridge, ship and boiler plates. The steel entering into the material from which plates are rolled is prepared to conform to standard specifications governing the above classes. Boiler plates are further divided (with reference to the grade of steel to be used for certain parts of the boiler) into flange, fire box and extra soft steel. Plates, after being rolled, have frequently an uneven surface, which is flattened by passing them through straightening rolls. Long plates are straightened by being held in place against guides and are hammered flat with wooden hammers. Plates, after being straightened and cooled, are transferred to the shearing department, usually adjoining the plate mill, where they are cut to size. Plates having irregular edges must be sheared. Universal mill plates have their edges rolled and need only be sheared on the ends. Universal mill plates are rolled from 18 to 60 inches in width.

Skelp

Skelp plate is a material used for the manufacture of tubes and pipes. It is rolled to such width and thickness as may be necessary to produce a certain diameter and strength of tubing. The edges of skelp plate are generally sheared for large sizes of pipe. When the edges of plate are rolled or cut to a beveled shape, it is called scarfed skelp, and is used for the manufacture of lap-welded pipes. Grooved skelp are plates rolled in a mill

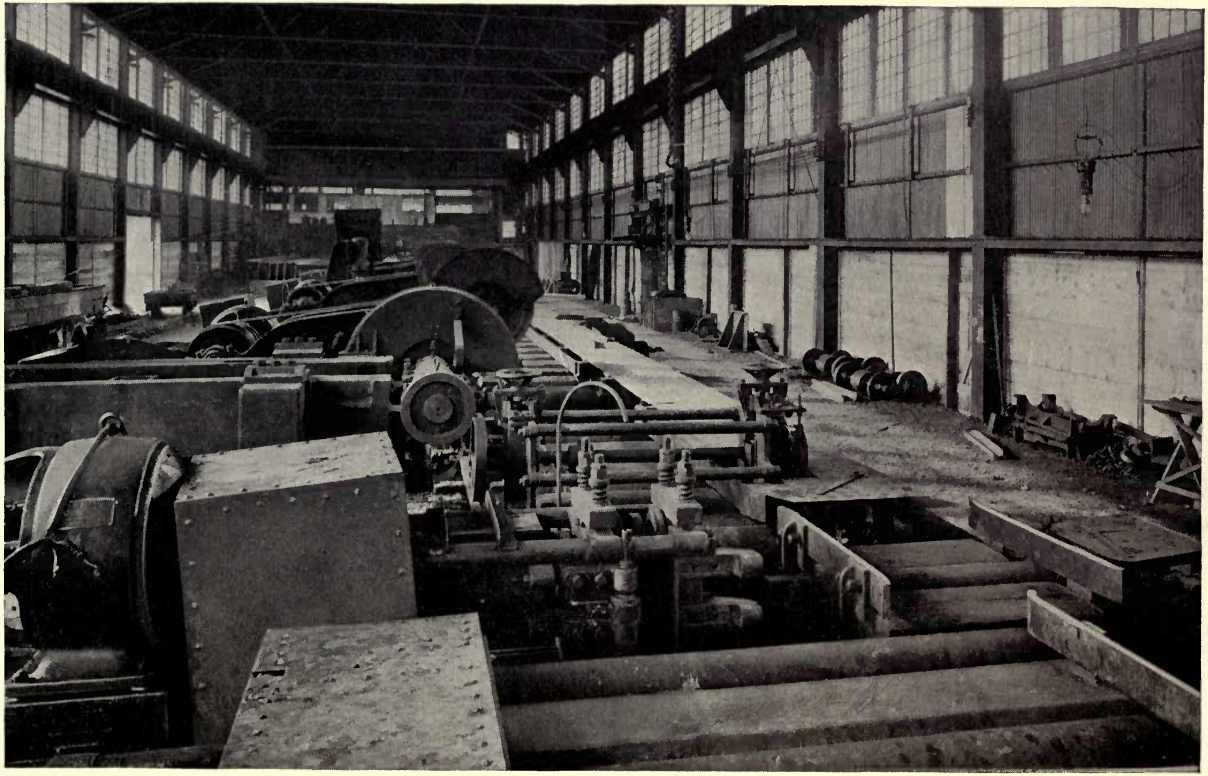

Fig. 18—Rail Cambering Machine, Bethlehem Steel Co., South Bethlehem, Pa.

having grooves cut into the rolls the width of the plates to be rolled.

Sheets

Sheets are rolled from sheet bars of such thickness and are sheared into such lengths that each piece will be of the exact weight to make the sheet required. The sheet bars are heated and rolled into sheets of the required thickness in mills called sheet mills. They are also, when specified, cold-rolled or pickled and cold-rolled, to meet special requirements. As the sheets become hard in the process of rolling, they must be annealed. This is accomplished in suitable furnaces. Sheet mills, as a rule, do not roll thinner than No. 30 gage. *Black sheets* is a term generally used to differentiate between sheets that are uncoated and those that are coated.

TABLE I

PRODUCTION OF IRON AND STEEL PLATES AND SHEETS

	Plates, No. 12 and thicker.			Sheets, No. 13 and thinner.		
	Iron,	Steel,	Total,	Iron,	Steel,	Total,
Years.	gr. tons.	gr. tons.	gr. tons.	gr. tons	gr. tons.	gr. tons.
1905.....	10,022	2,031,184	2,041,206	62,134	1,428,890	1,491,024
1906.....	23,333	2,508,219	2,531,552	51,040	1,599,564	1,650,604
1907.....	30,277	2,629,783	2,660,060	43,761	1,545,011	1,588,772
1908.....	31,679	1,239,342	1,271,021	22,354	1,356,318	1,378,672
1909.....	32,332	2,346,766	2,379,098	43,870	1,811,378	1,855,248
1910.....	37,763	2,769,965	2,807,728	53,355	2,094,401	2,147,756
1911.....	46,147	2,288,194	2,334,341	43,280	2,110,428	2,153,708
1912.....	33,349	3,001,851	3,035,200	41,695	2,798,185	2,839,880

Nail plates are used for the manufacture of cut nails. The plates must be of uniform thickness. This product is being rapidly eliminated owing to the increasing use of wire nails.

Table I gives the production of iron and steel plates and sheets from 1905 to 1912.

Group Four

By forgings, group four, is understood the product obtained by the various steps or stages of heating, pressing or hammering an ingot, bloom, slab and other rolled products into a definite form

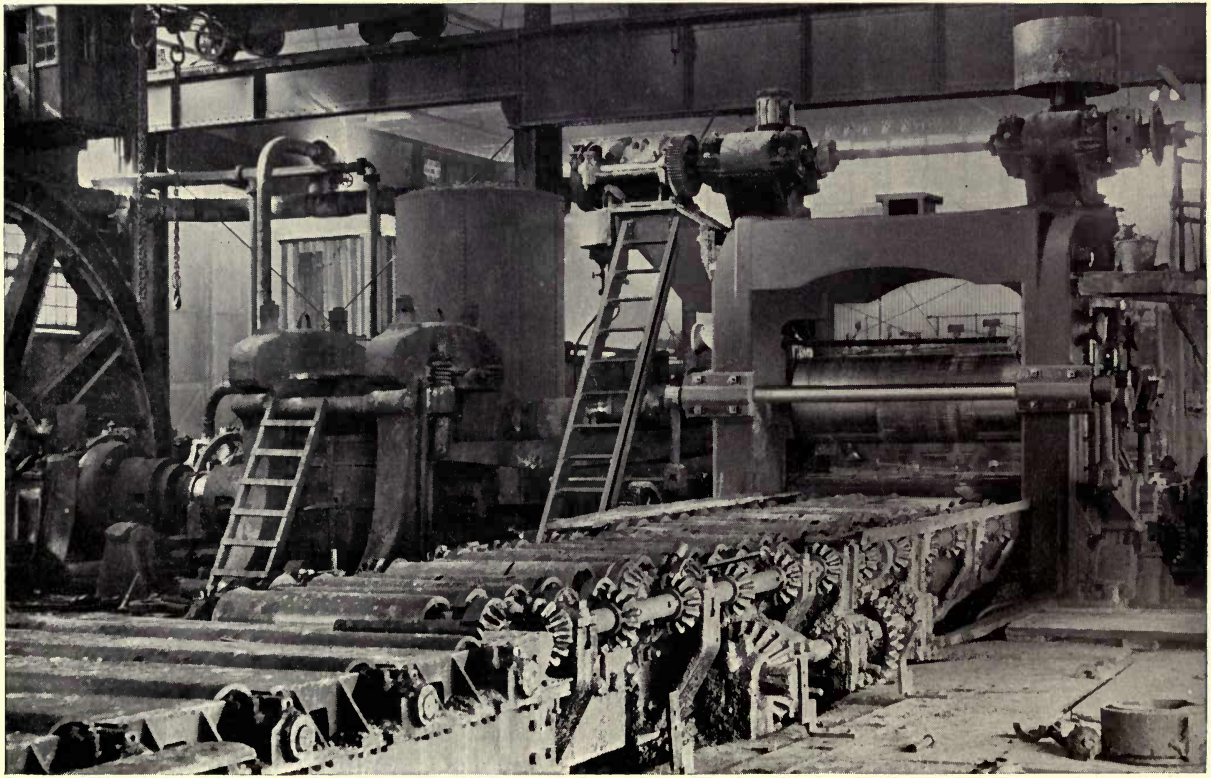

Fig. 19—84-inch Plate Mill, LaBelle Iron Works, Steubenville, O.

or shape. Work performed on forged articles, after the completion of the forging process, such as machine work, advances them beyond the class of product known as forgings, although such finishing process or work is frequently performed in the same shops where the forging of the article takes place.

Armor plate is a specially heavy plate, forged from a large ingot by means of powerful hydraulic presses. It is used for the protective sheathing of war vessels to withstand the penetration of projectiles. After being forged the plates are finished to exact dimensions in machine shops with specially equipped tools and appliances for this class of work. There are many patented processes for the treatment of armor plate for producing a tough material with a hard surface, the most notable being the Krupp and Harvey processes. The manufacture of armor plate is carried on in works close to the steel works, where the armor plate ingots are cast, and is an industry requiring great skill and careful manipulation so that the product will meet the exact requirements of ordnance specifications.

Railroad Axles

Railroad axles are forged shafts having wheel seats and journals carrying the wheels, and supporting the truck or frame of locomotives, tenders or cars. Steel entering into the material from which axles are forged is made to conform to special specifications depending upon whether the axle is to be used for car or tender trucks, driving or engine trucks.

Railroad axles are forged in one heat, from blooms or billets, under a steam hammer, or high-speed forging press. After the forging process, they are transferred to the machine shop, where they are cut to length and centered. Frequently, axles are rough-turned in the same shop, and sometimes finished complete ready to receive the wheels.

Axles are tested for strength before being shipped, and must conform to certain specifications. After being tested, they are stamped with the melt number and initials of the maker.

The plants manufacturing this class of forgings are called axle works, and are located close to the steel works, where the blanks or blooms are rolled.

Forged Wheels

Wheels, like axles, are produced in works specially equipped for this class of forging. There are numerous processes for forging wheels, but the common practice consists in pressing an octagonal ingot into a round slab. The slab is reheated, punched and pressed to the form of a wheel; this form is again reheated and placed in a specially constructed rolling mill, which gives the wheel its final shape. These various operations are shown graphically in Fig. 14. After leaving the rolling mill, the wheel is machined, bored and finished ready to be pressed on the axle. Special specifications govern the quality of steel from which the wheels are produced, and tests are made similar to those for axles.

Tires are circular forgings used to form the treads of wheels. They are shrunk to the outer rim of the wheels, and securely fastened thereto. They are forged from ingots of octagonal shape by pressing and punching to an annular form, and subsequently expanding the ring in a hydraulic press, and are finally rolled to shape. After rolling, the tire is turned to exact size in the machine shop, and finished ready to be shrunk upon the wheel. The manufacture is carried on in separate shops with tools and appliances specially designed for the purpose, similar to that of wheels and axles.

Drop Forgings

Drop forgings is the product obtained by forging a suitable piece of steel between dies under a hammer, the lower die being attached to the anvil block, while the upper die is fastened to the hammer itself, and moves up and down with it. From the drop hammer, the forging is placed in a trimming press to remove the excess metal, called flash, before being machined. The process is used for the manufacture of articles in large quantities.

Production of Rolled Iron and Steel

The following table gives the production, in gross tons, of all leading articles of finished rolled iron and steel in 1911, and total production from 1904 to 1910, inclusive:

Article.	1911. Iron, gross tons	1911. Steel, gross tons.	1911. Total, gross tons.	T't'l gross tons in 1910.
Rails	234	2,822,556	2,822,790	3,636,031
Structural shapes	811	1,911,556	1,912,367	2,266,890
Plates and sheets	89,427	4,398,622	4,488,049	4,955,484
Nail and spike plate	9,951	38,571	48,522	45,294
Wire rods	610	2,449,843	2,450,453	2,241,830
Rolled forging bl'ms and billets	363	230,752	231,115	459,933
Merchant bars	835,625	2,211,737	3,047,362	3,785,731
Bars for reinforced concrete work	2,388	256,353	258,741	241,109
Skelp, flue, etc	322,397	1,658,276	1,980,673	1,828,194
Splice bars	14,694	148,876	163,570	223,022
Hoops	.....	225,074	225,074	262,214
Bands and cot'n-ties	12	342,798	342,810	424,979
Sheet piling	.....	22,827	22,827	26,598
Railroad ties	.....	39,197	39,197	49,048
All other finished rolled product	184,103	821,518	1,005,621	1,174,922
Total for 1911	1,460,615	17,578,556	19,039,171	21,621,279
Total for 1910	1,740,156	19,881,123	21,621,279	
Total for 1909	1,709,431	17,935,259	19,644,690	
Total for 1908	1,238,449	10,589,744	11,828,193	
Total for 1907	2,200,086	17,664,736	19,864,822	
Total for 1906	2,186,557	17,019,911	19,588,468	
Total for 1905	2,059,990	14,780,025	16,840,015	
Total for 1904	1,760,084	10,253,297	12,013,381	

Production of Forged Iron and Steel

The production of forged iron and steel axles, shaftings, anchors, armor plate, gun carriages, etc., by rolling mills and steel works from 1906 to 1911, was as follows, in gross tons of 2,240 pounds:

	Production.		
Yr.	Iron, gr. tns.	Steel, gr. tns.	Total, gr. tns.
1906	19,148	333,488	352,636
1907	23,772	357,033	380,805
1908	13,646	117,497	131,143
1909	25,523	223,741	249,264
1910	20,410	299,452	319,862
1911	4,034	214,202	218,236

Total Production of Finished Rolled Iron and Steel

The total production of iron and steel rails, plates, sheets, wire rods, structural shapes, nail plates, bars and all other finished rolled products from 1887 to 1911, is given below. Rolled forging blooms and forging billets are included from 1905. Prior to 1892 structural shapes were included with bars, hoops, etc.

Year.	Iron and steel rails, gr. tons.	Plates and sheets, except nail plate, gr. tons.	Wire rods, gr. tons.	Struct'l shapes, not including plates, gr. tons.	Nail plate, gross tons.	Bars, hoops and all other forms, gr. tons.	Total gr. tons.
1887	2,139,640	603,355	.....	.....	308,432	2,184,275	5,235,706
1888	1,403,700	609,827	279,769	.....	289,891	2,034,162	4,617,349
1889	1,522,204	716,496	363,851	.....	259,409	2,374,968	5,236,928
1890	1,885,307	809,981	457,099	.....	251,828	2,618,660	6,022,875
1891	1,307,176	678,927	536,607	.....	223,312	2,644,941	5,390,963
1892	1,551,844	751,460	627,829	453,957	201,242	2,579,482	6,165,814
1893	1,136,458	674,345	537,272	387,307	136,113	2,104,190	4,975,685
1894	1,021,772	682,900	673,402	360,305	108,262	1,795,570	4,642,211
1895	1,306,135	991,459	791,130	517,920	95,085	2,487,845	6,189,574
1896	1,122,010	965,776	623,986	495,571	72,137	2,236,361	5,515,841
1897	1,647,892	1,207,286	970,736	583,790	94,054	2,497,970	7,001,728
1898	1,981,241	1,448,301	1,071,683	702,197	70,188	3,239,760	8,513,370
1899	2,272,700	1,903,505	1,036,398	850,376	85,015	4,146,425	10,294,419
1900	2,385,682	1,794,528	846,291	815,161	70,245	3,575,536	9,487,443
1901	2,874,639	2,254,425	1,365,934	1,013,150	68,850	4,772,329	12,349,327
1902	2,947,933	2,665,409	1,574,293	1,300,326	72,936	5,383,219	13,944,116
1903	2,992,477	2,599,665	1,503,455	1,095,813	64,102	4,952,185	13,207,697
1904	2,284,711	2,421,398	1,699,028	949,146	61,601	4,597,497	12,013,381
1905	3,375,929	3,532,230	1,808,688	1,660,519	64,542	6,398,107	16,840,015
1906	3,977,887	4,182,156	1,871,614	2,118,772	54,211	7,383,828	19,588,468
1907	3,633,654	4,248,832	2,017,583	1,940,352	52,027	7,972,374	19,864,822
1908	1,921,015	2,649,693	1,816,949	1,083,181	45,747	4,311,608	11,828,193
1909	3,023,845	4,234,346	2,335,685	2,275,562	63,746	7,711,506	19,644,690
1910	3,636,031	4,955,484	2,241,830	2,266,890	45,294	8,475,750	21,621,279
1911	2,822,790	4,488,049	2,450,453	1,912,367	48,522	7,316,990	19,039,171
1912	3,327,915	5,875,080	2,653,553	2,846,487			

Chapter IV

The Wire Industry

WIRE is the name given to small metal filaments produced in pieces of considerable length in the process of drawing, in other words, successively reducing and extending the section by repeatedly pulling it cold through tapered holes in a die plate. Most wire is of round cross-section, but it may also be square, flat, oval or have other forms, and is then known as shaped wire. Iron or steel wire is drawn down to 0.007 inch, or No. 34 B. W. G. or finer. The United States government has adopted the B. W. G. as standard for measuring the thickness, and classes all iron or steel rolled or drawn to a thickness of less than No. 6 B. W. G. (0.203 inch) as wire.

Wire may be produced from all ductile metals, but iron and steel wires have by far the greatest application and comprise nearly one-eighth of the entire iron and steel output.

The main articles produced from wire are nails, spikes, barbed wire, wire rope, telegraph and telephone wire, coiled spring steel fence wire, chain wire, various forms of woven wire and wire netting, wire hoop, wire bale ties, springs, piano wire, rivets, screws, staples, tacks, etc. Large quantities of various classes of wire are used in the manufacture of articles for household and industrial purposes having innumerable applications.

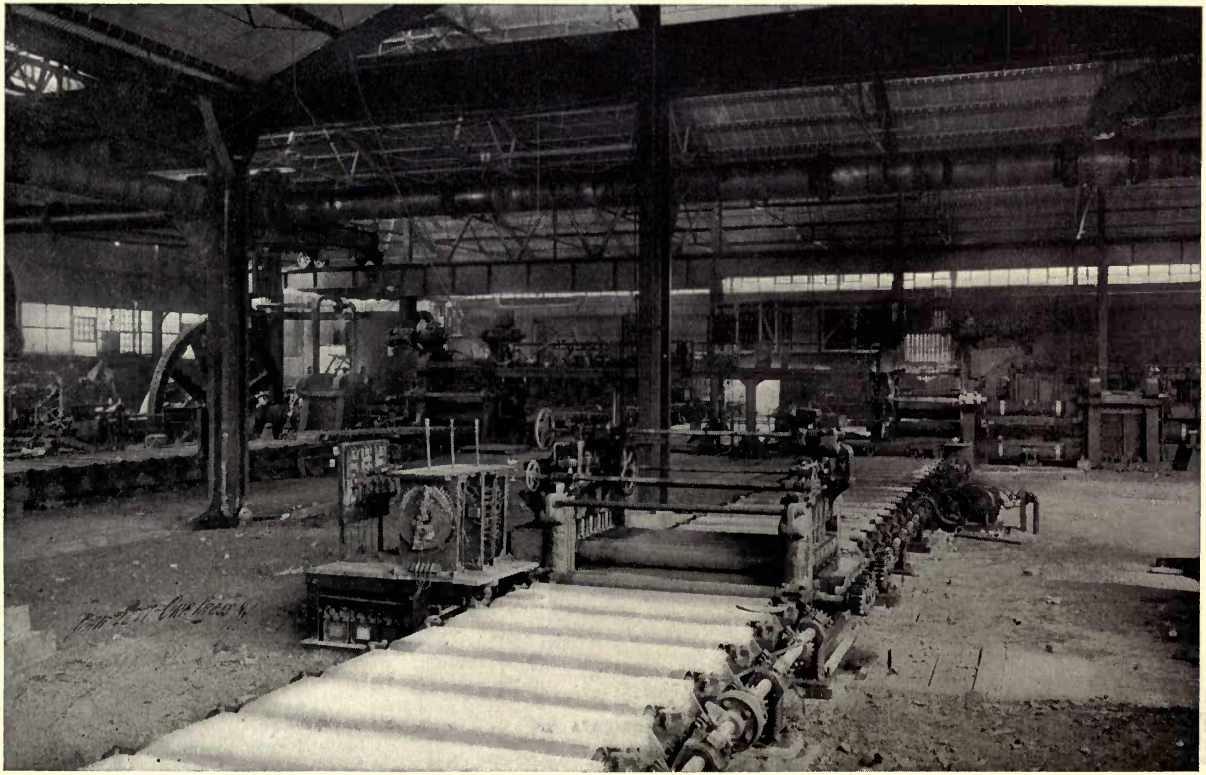

Fig. 20—Plate Mill and Tables, LaBelle Iron Works, Steubenville, O.

Wire Drawing

The drawing of wire is performed in a drawbench, which consists of a die-plate and a driven reel for pulling the wire through the die. In order to reduce the friction caused by drawing, the wire is coated with a lubricant. The drawing may be either by the wet or dry process; the latter is generally used on sizes down to No. 18 and employs tallow or soap-stone as a lubricant, while the former is used for finer wires and a lubricant of rye meal flour and water is used. When a coppered finish is required, a solution of copper sulphate is applied to the wire and then it is given the final drawing. Wire, after being drawn through several dies, becomes hard and must be annealed to render it soft and pliable; it is then pickled, washed and cleaned from scale before being drawn down any further. A large quantity of wire is galvanized, which consists in coating the metal with a thin layer of spelter. Before being coated, the wire is annealed and cleaned, passed through a flux bath and then through molten spelter. The excess of spelter is removed by passing through asbestos wipers, or charcoal headers. A large number of wires are thus treated in the same apparatus at the same time.

Nails

Nails are short pieces of metal pointed at one end and forged with a head on the other end; they are used for fastening and joining purposes. The shaft of the nail may be of various forms, but is usually round or square. With reference to the method of manufacture, there are two kinds of nails, namely, wire nails and cut nails, wire nails being by far the most important. They are manufactured from cold-drawn wire in automatic machines, called nail machines. Cut nails are produced from nail plates by an automatic cutting process. Spikes are large nails. Standard railroad spikes are a special design of spike manufactured from hot or cold bar iron or steel wire in automatic machines, called spike machines. Nails and spikes are made in a great many forms and sizes, and are named after the

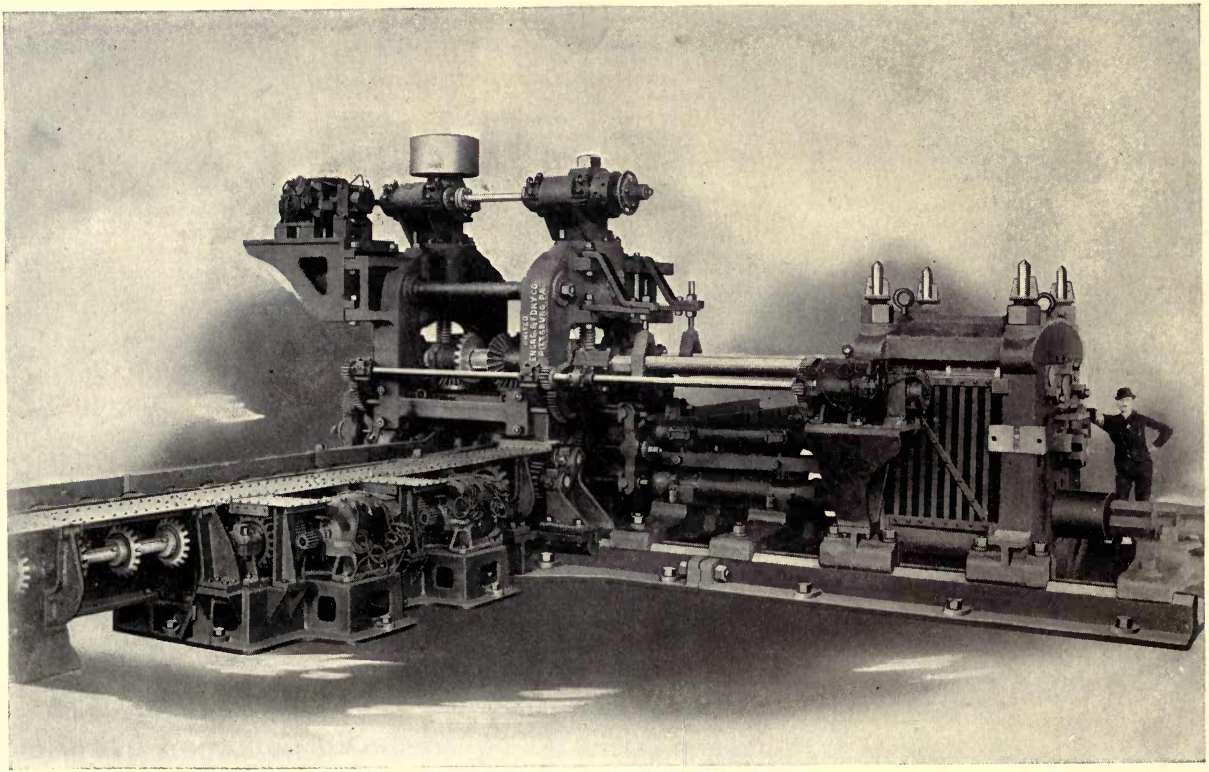

Fig. 21—30-inch Universal Plate Mill

kind of work to which they are applied. They are packed in wooden kegs, each generally weighing 100 to 200 pounds, respectively, and thus shipped. Large quantities also are packed in small cartons and boxes.

Production of Cut and Wire Nails

Table II gives the production in kegs of 100 pounds of standard sizes of cut nails and spikes cut from plates, in the 14 years from 1896 to 1912; also the production of standard sizes of wire nails during the same period. The annual increase of

TABLE II

Years.	Cut nails, kegs.	Kegs of Wire nails, kegs.	100 pounds. Total, kegs.	Excess of wire nails over cut.
1896	1,615,870	4,719,860	6,335,730	3,103,990
1897	2,106,799	8,997,245	11,104,044	6,890,446
1898	1,572,221	7,418,475	8,990,696	5,846,254
1899	1,904,340	7,618,130	9,522,470	5,713,790
1900	1,573,494	7,233,979	8,807,473	5,660,485
1901	1,542,240	9,803,822	11,346,062	8,261,582
1902	1,633,762	10,982,246	12,616,008	9,348,484
1903	1,435,893	9,631,661	11,067,554	8,196,768
1904	1,283,362	11,926,661	13,210,023	10,643,299
1905	1,357,549	10,854,892	12,212,441	9,497,343
1906	1,189,239	11,486,647	12,675,886	10,297,408
1907	1,109,138	11,731,044	12,840,182	10,621,906
1908	956,182	10,662,972	11,619,154	9,706,790
1909	1,207,597	13,916,053	15,123,650	12,708,456
1910	1,005,233	12,704,902	13,710,135	11,699,669
1911	967,636	13,437,778	14,405,414	12,470,142
1912	978,415	14,659,700	15,638,115	13,681,285

wire nails over cut nails in the 13 years also is shown. The maximum production of cut nails was reached in 1886, when 8,160,973 kegs were made, and the maximum production of wire nails in 1912, when 14,659,700 kegs were made.

Barbed Wire

Barbed wire consists of two twisted wires to which are securely fastened pointed wires called barbs, at intervals of 3

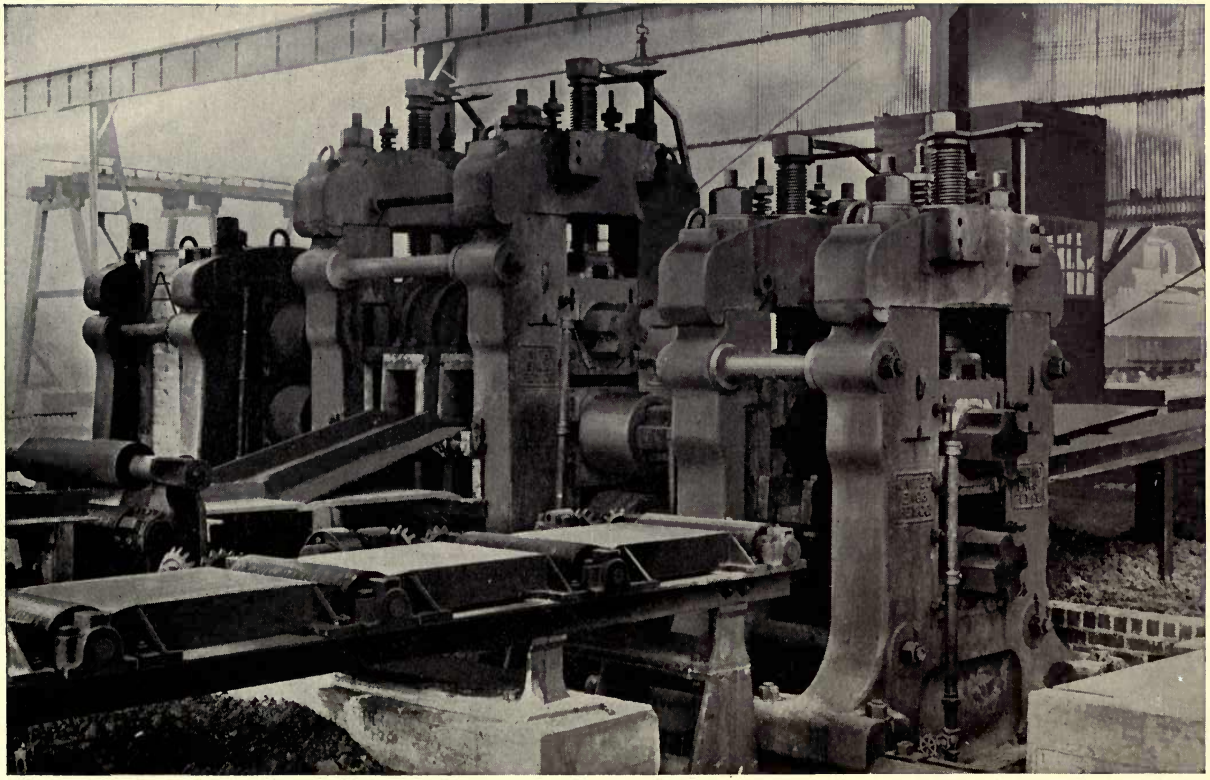

Fig. 22—24-inch Sheet Bar Mill, Andrews Steel Co., Newport, Ky.

to 6 inches. Barbed wire, generally made from No. 12 to No. 15 gage, is manufactured by automatic machines and is put up on reels from 65 to 85 pounds, called *pony* reels; and on reels from 100 to 110 pounds, called *regular* or *catch-weight* reels. The recent practice is to put 80 rods on a reel, the weights of which vary from 50 to 90 pounds.

Wire rope is composed of a number of wires wound in spirals around a core of lubricated hemp or a wire center. Various kinds of wire rope are manufactured from ⅛ inch in diameter up to 2½ to 3 inches in diameter, or larger. The use to which the rope is to be put governs its construction, in other words, the number of wires and strands, and the quality of steel or iron which enters into its manufacture. Wire rope is wound on wooden reels or in coils, and is shipped bright, tinned or galvanized.

Telephone or telegraph wire is drawn almost exclusively from iron stock made specially for this purpose. It is galvanized to insure ample protection from corrosion under extreme weather conditions. It is coiled and shipped in bundles of convenient size and weight.

Fence wire is made of steel, any gage, from No. 7 to No. 19. It is black, bright, galvanized or painted. Coiled spring steel fence wire is generally made of Nos. 7 to 14 gage, slightly crimped, in other words, bent uniformly at regular intervals from a straight line. It is usually galvanized and shipped in bundles of convenient size and weight.

Woven Wire

Woven fabric consists of wire fencing, netting, screens, guards, wire cloth, concrete reinforcement fabric, etc. It is manufactured by interlocking, superposing one wire about the other and interweaving them, or by twisting the wires around each other, or by joining the wires at their intersection by means of clips, or electric welding.

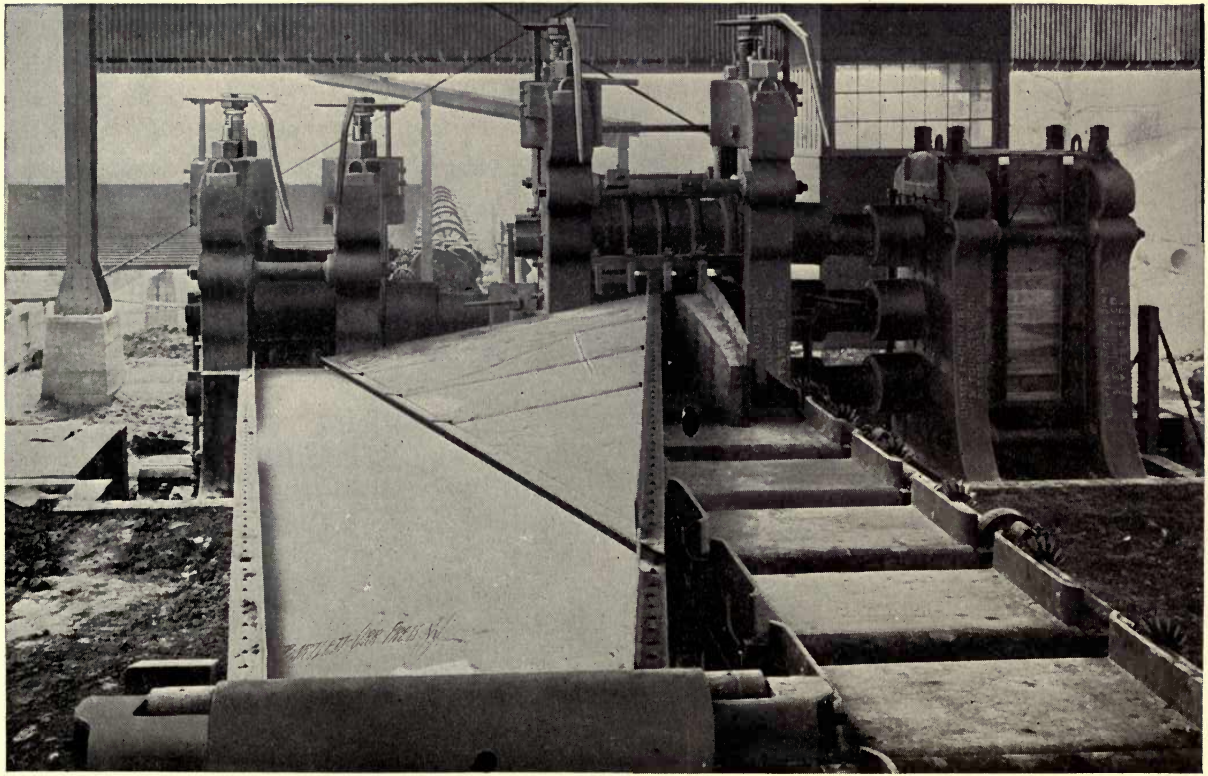

Fig. 23—24-inch Sheet Bar Mill, Andrews Steel Co., Newport, Ky.

The fabrics are produced on a large scale by specially designed automatic machinery and are shipped flat in rolls, or on reels bright, galvanized, tinned or painted.

Bale ties are used almost exclusively for baling hay, straw, shavings, paper, rags, etc., and are shipped in bundles containing 250 ties and made of wire from No. 9 to No. 20 gages.

Wire hoops are used to replace wooden and flat steel hoops, particularly the bilge hoops on slack cooperage barrels and kegs. They are made of wire from 5/16 inch diameter to No. 16 gage, and the ends are joined by electric welding or twisting.

Rivets

Rivets are cylindrical pins with a head on one end, used for uniting two or more pieces of material. The head is formed on the rivet at the factory by an automatic machine and the other head is formed when the material is riveted together, either by hand or pneumatic tools. The rod from which they are produced is called rivet rod or wire. Rivets of greater diameter than ⅝ inch are made from heated bars; less than this size are upset cold.

Bolts and Nuts

Bolts are short, cylindrical pins with a head on one end and a thread cut on the other end. In conjunction with a nut they serve for uniting parts of materials.

Nuts are square or hexagonal pieces of metal, about the thickness of the bolt, but are provided with a hole; they are tapped with a thread to match the thread cut on the bolt to which they belong.

Washers are plain or conical plates provided with a hole to fit the shaft of the bolt to which they belong and are used to provide a better contact between the nut and the material united by a nut and bolt preventing the nut from injuring the material, and increasing the bearing area.

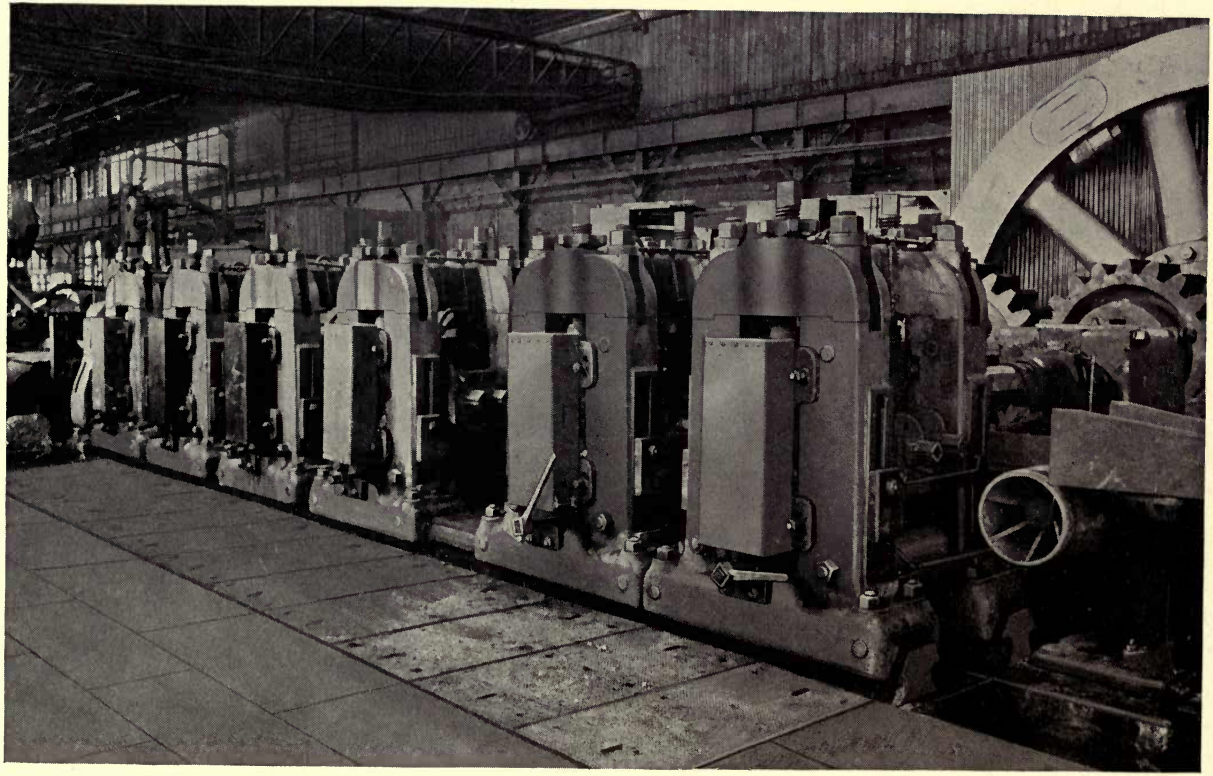

Fig. 24—A 16-inch, Morgan Continuous Mill at the Plant of the Dominion Iron & Steel Co., Cape Breton, N. S.

Bolts and nuts are formed in special machines from cold wire for the smaller sizes, and from hot bars or bolt and nut iron for the larger sizes. The thread is cut or rolled on the bolt blank and the punched nut is tapped by special thread-cutting machines.

Screws are short, conical pins provided with a slotted head on one end and they are threaded in the shaft to a point. The smaller sizes are made from wire screw rods, the larger sizes from rods or bar iron. Special automatic machines are used for their manufacture.

Chains

Chains consist of a series of links interlaced with the adjoining links; they are only useful to transmit tension. Chains may be classified according to their application into ornamental, load, driving and stud link cable chains. Classified according to the material used and the process of manufacture, they are known as plate, wire, forged or welded and weldless chains, respectively. Ornamental chain is never subjected to severe strains and its design varies according to the taste of the maker or user. Generally, ornamental chain is manufactured of expensive material and is not used for industrial purposes.

Plate chain is an intermediate style between the ornamental and the load chain and is commonly used for attaching loose pieces, such as keys, plugs for plumbing work, cups, sash weights, etc. Most of these chains are stamped from metal strips with a hole in each end; these are doubled and the ends are secured by inserting and doubling the next link.

Wire chain forms an intermediate product between plate and welded load chain. The links either are in the form of an oval made of wire bent around a form with both ends butting against each other, or they are shaped like the figure eight with two openings, the ends butting against the sides of the wire piece near the middle.

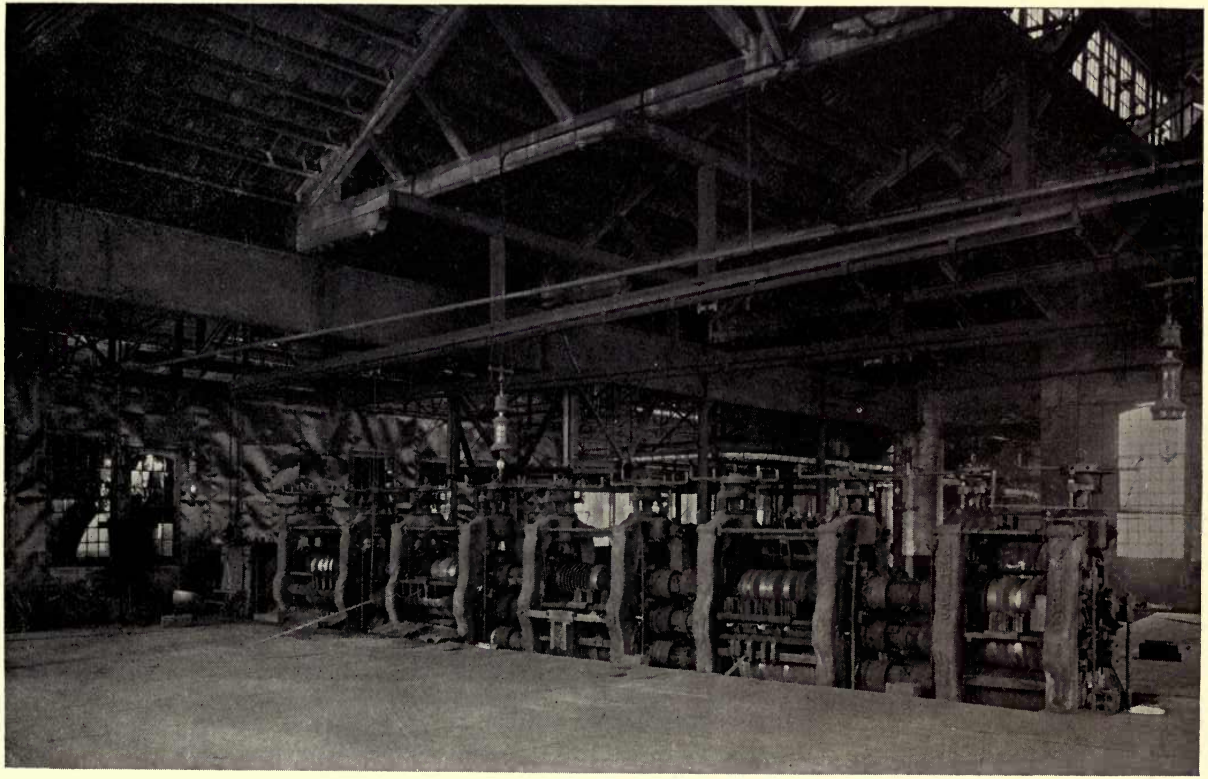

Fig. 25—Motor-Driven, 20-inch Merchant Mill, Singer Mfg. Co., Elizabeth, N. J.

Welded Chains

Welded chains are by far the most important, as the greater part of all chains in use are welded. They may be either hand or machine-made.

The hand-made chain is formed and welded by hand and is finished by blows of hand hammers, while the machine-made is wound into shape by machinery from coils or bars, cut into links by the same power, and is welded by dies operated by power or foot-driven hammers.

Machine-made chains cover sizes varying from 3/16 to 1¼ inches in diameter, and are sold per 100-pound casks in three qualities, namely, proof coil chain, B.B. coil chain and B.B.B. coil chain.

Hand-made chains cover all sizes, 1½ inch and heavier, and include stud link chains, which have an iron separator or stud pressed into the sides of the link; the latter are used largely for marine service. Hand-made chains are known and sold as crane or dredge chain and stud link chain.

Open-hearth steel is used largely in chain manufacture, but the better grades are made of the best refined iron. Nearly all chains are tested by the manufacturer before being shipped. The chains are subjected to a test strain, one-third in excess of that at which they should be worked in safety.

Weldless chains are either rolled or cast. There are numerous patented processes for producing rolled weldless chains, one of the most notable being a German invention, known as the Klatte process. Cast chains, even when cast from steel and subsequently rolled, have not found ordinary industrial application. Chains are shipped plain, or blackened if it is desired to protect them from rust during transit.

Driving chains such as link belt, roller, rocker, silent drive, etc., are of special design, requiring accurate machine finish, and in conjunction with suitable sprocket or gear wheels, form a part of the driving mechanism of some machines.

Horse Shoes

Horse shoes, including shoes for mules and oxen, are now manufactured chiefly in rolling mills by automatic machinery. According to the most recent estimate, at least 100,000 tons of material are used annually for this product, of which 75 per cent is machine-made. These shoes are manufactured in a wide variety of patterns, sizes and weights, ranging from those used by ponies and jacks to those worn by the largest draft horses. The sizes vary from No. 000 to No. 8, and the weights from four or five to 60 ounces.

Toe Calks

Toe calks are small steel bars welded on to the toe of the shoe and are made in all sizes to suit the shoe for which they are used.

Chapter V

Tube and Pipe Industry

TUBES and pipes are interchangeable names given to long, hollow, metallic cylinders, open at both ends. Tubes are generally rated by their outside diameter, and pipes according to their nominal inside diameter. They are made from various materials, the most important being wrought steel, cast iron and wrought iron.

Cast iron pipes are used mainly for the conveyance of water having pressures less than 100 pounds per square inch. They are frequently cast with a bell mouth at one end, into which fits the plain end of the pipe to which it is connected. The space between the plain pipe and bell is caulked with some pliable material. such as lead, to make it a tight joint. For high pressure, flanges are cast on the ends, which are connected with bolts. Cast pipes are manufactured in foundries specially built for this purpose. After being cast, they are usually dipped in hot asphalt before shipping.

Wrought steel pipes may be divided into riveted and welded. Riveted pipes are generally of diameters larger than 30 inches and are used for hydraulic purposes. They are made from plates overlapping each other and are united by means of rivets.

Welded pipes may be either butt-welded or lap-welded. Welded wrought steel pipe is used most extensively and enters into the construction of oil, gas and water lines. It is used in

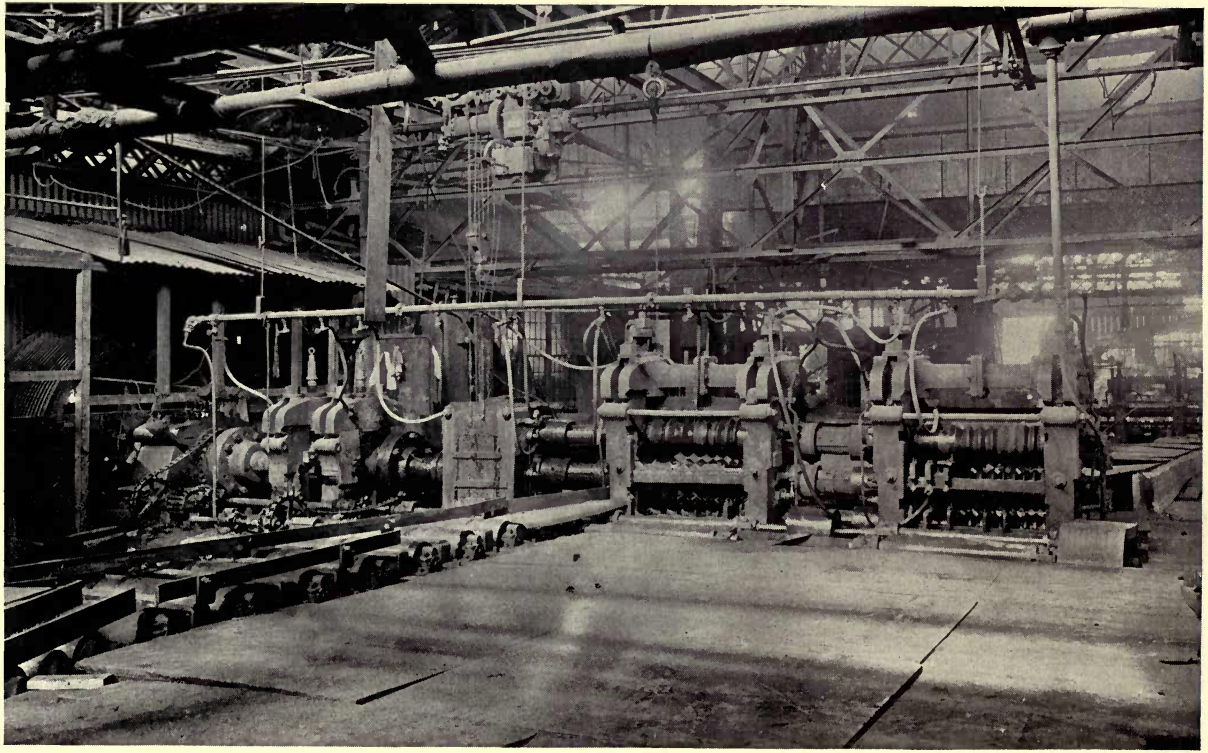

Fig. 26—16-inch Merchant Mill, Illinois Steel Co., Milwaukee

railroad cars for brake beams, air brake cylinders, for house heating, plumbing, gas fitting and electric conduits, boiler flues, trolley poles, railings, posts, bent coils, air lines, etc.

Butt-welded tubes are made from skelp, heated to a welding temperature by pulling it through a bell-shaped die, which curls the plate and welds the edges together. Butt-welded tubes are only made up to 3 inches in diameter inclusive and are not as strong as lap-welded.

Lap-Welded Tubes

Lap-welded tubes are made from heated skelp, which has its edges beveled (scarfed), and is passed through bending rolls. This process curls the skelp into the shape of a pipe; it is then reheated to a welding temperature and is passed through a pair of welding rolls, between which is fixed a mandrel on the end of a long rod. The roll presses the two edges of the scarfed plate over the mandrel, welding them together. Lap-welded pipe is made up to 30 inches in diameter inclusive. All tubes, after being welded, are run through sizing rolls to give them true outside dimensions; they are then straightened in cross rolls, cooled, cut to length and tested under hydraulic pressure.

Welded tubes larger than 30 inches in diameter are made from bent plates, the edges of which are raised to a welding heat by a special burner; the plates then are welded together by a machine constructed for this purpose.

Seamless Tubes

A seamless tube is one in which the walls have never been separated from the time the metal was in a molten condition to the time of the completion of the tube. These tubes are manufactured from solid steel blooms or billets and of such length as to produce a standard length of tube. There are several processes for manufacturing seamless tubing, but the general method is to heat the billet and to pass it through a piercing machine, over

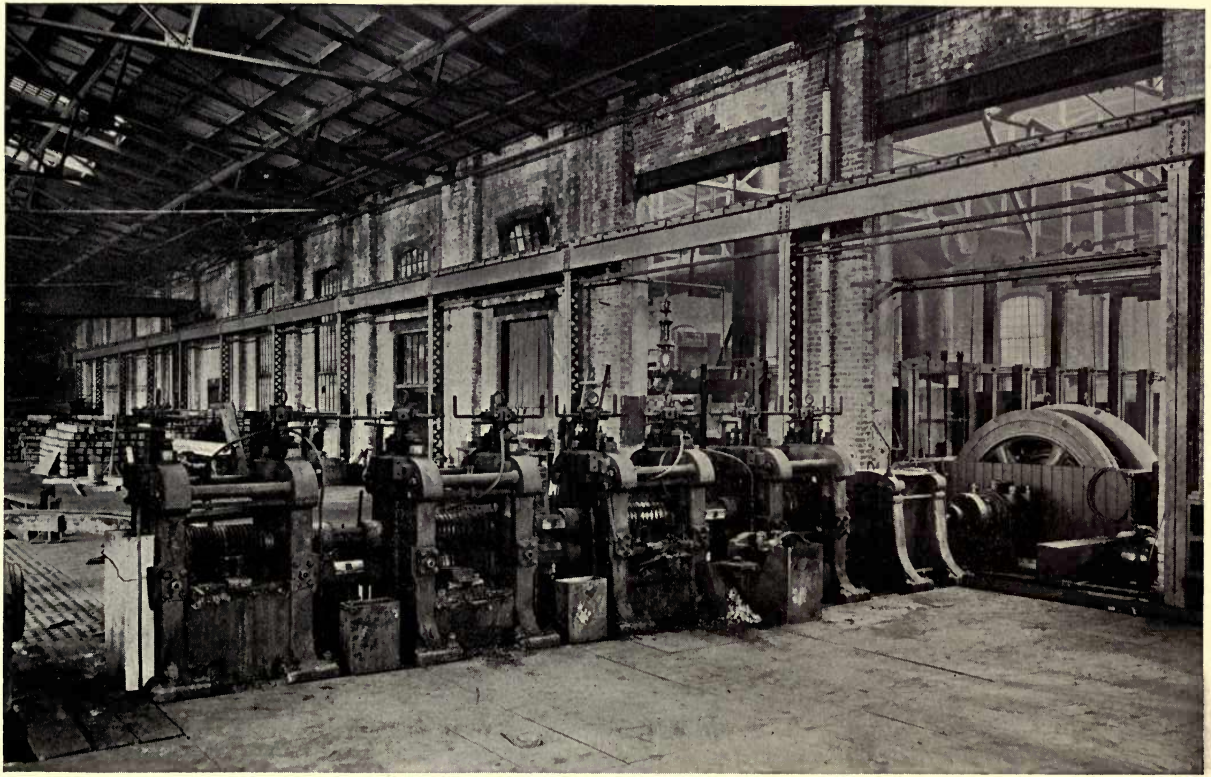

Fig. 27—Motor-Driven, 10-inch Merchant Mill, Singer Mfg Co., Elizabeth, N. J.

a mandrel. This process pierces a hole through the center of the billet, after which the tube is rolled successively between rolls and over a mandrel, until the proper diameter and thickness of wall is obtained. Tubes thus produced either may be hot or cold-drawn over a mandrel to final size. In cold-drawing, the tube is first pickled in a bath of dilute sulphuric acid to remove all scale; it is rinsed in water and drawn without further treatment. The tube must be annealed and pickled after each drawing.

Cold drawn tubes, from ⅜ to 1½ inches outside diameter and from No. 16 to No. 23 B. W. G. are generally known as bicycle tubing. Tubes, 1 to 4 inches in diameter and No. 13 to No. 6 B. W. G., are used for boiler purposes. Tubes of other thicknesses than those enumerated, generally are termed mechanical tubes and are used for parts of many classes of machinery such as bushings, hollow shafts, spindles, axles, collars, rings, ferrules, pump barrels, etc.

Seamless tubes over 5½ inches in diameter and up to about 20 inches are, as a rule, of shorter length and are manufactured from plates. The process consists in first pressing the form of a cup from a heated, circular plate which, after reheating, is forced through a succession of dies by a punch or mandrel inserted in the cup, until the thickness of the walls of the now hollow vessel have been reduced materially. Further reduction in thickness is obtained by subsequent drawing similar to that of seamless tubes. Cylinders for compressed gases, which are subjected to great pressure, are made in this manner, the open end being swaged down and is provided with a suitable connection. Tube works operate, in addition to their tube mills, large departments for finishing the pipe after it leaves the testing bench. This work consists in threading, upsetting, bending, flanging, etc.

As pipes are commercially not over 20 feet in length, they must be coupled, in other words, they must be provided with means for connecting them to form pipe lines. This is accomplished by various forms of couplings. These either may be

screwed couplings or flanged connections, both types being fabricated in departments containing special machinery for this purpose. Most gas and water pipe is galvanized and this process is carried on in a separate shop with special mechanical means for galvanizing.

Commercial pipe is sold at a list price per foot or bundle and not by weight, except hot-drawn seamless tubing above 5½ inches outside diameter, which is sold at a net price per pound. Standard weight is shipped with threads and couplings, while standard extra strong pipe is shipped with plain ends, unless otherwise ordered. Pipe will vary 5 per cent above and 5 per cent below the weight per foot ordered and stock lengths are 16 to 18 and 20 feet. In the United States over 3,500,000 tons of pipe and tubular goods are produced each year.

Chapter VI

Tin and Terne Plate Industry

TIN plate (tinned plates) are sheets of steel, generally from No. 16 to No. 38 gage, coated with tin in order to protect them from corrosion. In heavy gages, they are sometimes called tinned sheets. The process of manufacture is practically the same up to the annealing operation as that for sheets. At this stage of manufacture, sheets to be tinned are first pickled to remove the scale; they are then washed with water in tanks to remove the acid and then they are annealed. After annealing, they are cold-rolled to a perfectly smooth surface in order that the finished tin plate will attain a high polish. The cold-rolled sheets are again annealed, pickled and washed. The sheets are then passed into and drawn through a bath of liquid tin by means of four to six pairs of rolls, which are immersed in it, the last set squeezing off the surplus metal. By the action of the rolls, the tin is distributed as evenly as possible on the surface of the sheets and the result is a smooth, bright, adhering coat of tin. The surface of the molten tin in the bath is covered with a layer of palm oil to prevent oxidation, and as some of this adheres to the plates, it is necessary to clean them. This is accomplished by a branning machine through which the plates are passed, a series of revolving brushes applying to the surface bran, or a mixture of sawdust and lime. The plates are next carefully inspected in the assorting room, those having defects being sep-

arated from the good sheets, the former being classed as *wasters* and the good sheets as *primes*; after this they are packed in wooden boxes which are marked with the sizes and gages of the plates contained therein, and whether *primes* or *wasters.*

The standard sizes of tin plates are 14 x 20 inches and 20 x 28 inches, and different trade terms are assigned to the plates, depending upon their sizes, weights per square foot, and the character and quantity of coating.

Terne Plates

Terne plates are manufactured in much the same manner as tin plates, except that the coating consists of a mixture of tin and lead running about 25 per cent of tin and 75 per cent of lead, and is, therefore, less expensive. They are called terne plates because made of three metals.

Taggers are thin sheets largely used for metal signs; they may be coated or uncoated; when coated, tin, lead or an admixture of these metals is used. Taggers tin is a name originally applied to sheets of tin plate lighter than the standard gage.

Corrugated sheets are sheets having corrugations or grooves pressed or rolled into the surface. They are usually produced by passing the sheets between a pair of rolls in the surface of which corrugations (grooves) have been cut.

Hot galvanizing consists in slowly passing the sheets through a bath of molten spelter (commercial zinc) and removing the superfluous zinc by iron brushes, or otherwise. Galvanizing is specially applied to corrugated sheets used for enclosing buildings.

Planished Sheets

Russian sheet iron, Russian iron or planished sheet, is a special grade of sheet with a glossy black appearance. It is produced by the rapid hammering of a pile of sheets. Sheets

toughened and hammered to obtain a polished surface are said to be planished. "Glanced" sheets used in this connection means brightened.

Enameling is the process of coating metals with a film of vitreous substance called enamel. The enamel is made in many different colors and usually is a secret composition. It is applied in the form of a powder or solution on the metal to which it is baked. The process is largely used for sheets, cooking utensils and sanitary fixtures, such as bath tubs, washstands, etc.

The following table gives the production, in the United States, of tin plate and terne plate by states in 1912:

States.	Tin plate, pounds.	Terne plate, pounds.	Total, pounds.
Pennsylvania	1,179,468,000	81,872,000	1,261,340,000
West Virginia	347,544,000	86,030,000	433,574,000
Ohio, Indiana, Illinois and Michigan	438,647,000	23,494,000	462,141,000
Total for 1912	1,965,659,000	191,396,000	2,157,055,000

Production of Tin Plate and Terne Plate in the United States Since the Beginning of the Tin Plate Industry in 1891

The following table gives the production of tin and terne plates in the United States from the beginning of the industry in 1891 to the end of 1912. From July 1, 1891, to June 30, 1897, the statistics were collected by Colonel Ira Ayer for the Treasury Department. From July 1, 1897, the statistics have been compiled from reliable sources of information, but chiefly from the records of the American Iron and Steel Association. For 1900, the figures are for the census year ending May 31, and for 1904 for the census year ending December 31, the statistics for these two years having been collected by the Bureau of the Census:

Years.	Tin plate, pounds.	Terne plate, pounds.	Total, pounds.
1891 (second six months)	368,400	1,868,343	2,236,743
1892 (calendar year)	13,921,296	28,197,896	42,119,192
1893	64,536,209	59,070,498	123,606,707
1894	102,223,407	64,120,002	166,343,409
1895	165,927,907	88,683,488	254,611,395
1896	270,151,785	89,058,013	359,209,798
1897 (first six months)	203,028,258	49,545,645	252,573,901
1897 (second six months)	.....	.....	322,205,619
1898 (calendar year)	.....	.....	732,289,600
1899	.....	.....	808,360,000
1900 (census year ending May 31)	707,718,239	141,285,783	849,004,022
1901 (calendar year)	.....	.....	894,411,840
1902	.....	.....	806,400,000
1903	.....	.....	1,075,200,000
1904 (census year ending Dec. 31)	867,526,985	158,857,866	1,026,384,851
1905 (calendar year)	.....	.....	1,105,440,000
1906	1,100,373,000	193,367,000	1,293,740,000
1907	996,650,000	156,447,000	1,153,097,000
1908	1,048,896,000	154,179,000	1,203,075,000
1909	1,179,858,000	190,930,000	1,370,788,000
1910	1,450,821,000	168,184,000	1,619,005,000
1911	1,597,629,000	158,441,000	1,756,070,000
1912	1,965,569,000	191,396,000	2,157,055,000

Iron and Steel Imports and Exports

The following tables compiled by the Bureau of Statistics of the Department of Commerce and Labor gives the quantities and values of United States imports and exports of iron and steel in the calendar year 1911[1]:

Rolling Mill Industry

	Exports.			Imports.		
	Gross	Av. val.		Gross	Av. val.	
Products.	tons.	per ton.	Values.	tons.	per ton.	Values.
Rails	420,874	.....	$12,229,045	3,414	.....	$ 89,327
Str. iron and stl..	223,493	.....	10,270,977	5,343	.....	186,358
Plates and sheets.	372,373	.....	18,153,304	2,453	.....	274,945
Wire rods	22,641	.....	659,066	15,483	.....	231,291
Ingots, bl'ms and billets	234,267	.....	5,150,518	29,205	.....	2,772,614
Merchant bars	125,606	.....	5,123,479	26,729	.....	1,202,363
Hoop, band and scroll	3,731	.....	163,853	.....	.....	.....
	1,402,985	$36.89	$51,750,242	82,627	$63.62	$5,256,898

Wire Industry

Barbed wire	96,754	.....	$5,294,223	Wire and	
All other wire	133,008	.....	6,343,373	articles	
Cut n'ls and spikes.	11,422	.....	470,515	made from	1,270,426
Wire n'ls and spikes.	53,614	.....	2,486,185	estimated	
All other, including tacks	12,848	.....	792,920	weight	
	307,646	$50.01	$15,387,216	27,000	1,270,426

Tube and Wire Industry

Pipes and fittings.	197,507	$58.11	$11,476,743	.....	.....	.....

Tin and Terne Plate Industry

Tin plate and terne plate	61,381	$77.81	$ 4,776,256	14,099	$76.77	$1,082,417

Summary

Rolling mill industry	1,402,985	.....	$51,750,242	82,627	.....	$5,256,898
Wire industry	307,646	.....	15,387,216	27,000	.....	1,270,426
Pipes and fit'gs..	197,507	.....	11,476,743	.....	.....	.....
Tin pl. and terne plate	61,381	.....	4,776,256	14,099	.....	1,082,417
Total tons when shipped	1,969,519	$42.34	$83,390,457	123,726	$61.50	$7,609,741

[1]For above industries only.

Basic Factors of Pig Iron Production in the United States, Germany and Great Britain

The following is a comparison of the general fundamental factors dictating the production of pig iron in the United States, Germany and Great Britain, with particular reference to the Pittsburgh district of the United States, the Rheinland-Westfalia district of Germany, and the Cleveland district of Great Britain:

United States, Pittsburgh district.	Germany, Rheinland district.	Great Britain, Cleveland district.
1. Abundance of ores in the Lake Superior district.	1. Scarcity of rich ores; abundance of lean ores (Siegerland, Lahn, Lothringen).	1. Scarcity of rich ores; abundance of lean ores (Cleveland iron stone).
2. Ore requirements almost entirely provided for by domestic supply; some foreign ore imported for tidewater and eastern furnaces.	2. The foreign supply from Sweden, Spain and the Mediterranean, amounts to about 30 per cent of the ore produced.	2. Foreign supply obtained from Sweden, Spain and the Mediterranean amounts to about 40 per cent of the ore production.
3. The ore transportation covers about 950 miles of waterway and 200 miles of railroad.	3. The ore transportation covers from 70 to 220 miles of railroad.	3. Close proximity of coal and ore. Longest haul for coke 30 miles of railroad.
4. Freight rates on ore, 0.7 cent per ton mile railroad and about 0.1 cent per ton mile, waterway.	4. Freight rates on ore, 0.1 cent per ton mile, railroad.	4. Freight rates on coke, 0.8 cent per ton mile railroad.
5. Carrying capacity of railroad cars 50 tons.	5. Carrying capacity of railroad cars 20 tons.	5. Carrying capacity of railroad cars 40 tons.

(*Continued on Page 63*)

BASIC FACTORS OF PIG IRON PRODUCTION—Concluded

United States, Pittsburgh district,	Germany, Rheinland district,	Great Britain, Cleveland district,
6. All ore cars provided with automatic dump.	6. Automatic dump cars not furnished.	6. Some automatic dump cars in use.
7. Scarcity of Connellsville coking coal in about 30 years.	7. Abundance of coking coal for several hundred years.	7. Scarcity of coking coal in about 50 years.
8. Distance of furnaces from tidewater, about 350 miles.	8. Distance of furnaces from tidewater, about 150 miles.	8. Distance of furnaces from tidewater, about 22 miles.
9. Large furnace dimensions.	9. Medium furnace dimensions.	9. Small and medium furnace dimensions.
10. It takes about 1¾ tons of ore to produce one ton of pig.	10. It takes about 2¼ tons of ore to produce one ton of pig.	10. It takes about 2½ tons of ore to produce one ton of pig.
11. It takes one ton of coke to produce one ton of pig.	11. It takes 1.10 tons of coke to produce one ton of pig.	11. It takes 1.15 tons of coke to produce one ton of pig.
12. The average production per year, per furnace, 90,000 tons.	12. The average production per year, per furnace, 50,000 tons.	12. The average production per year, per furnace, 35,000 tons.
13. High cost of daily labor.	13. Low cost of daily labor.	13. Low cost of daily labor.
14. No industrial restrictions or charges.	14. High industrial restrictions or charges.	14. Low industrial restrictions or charges.
15. Protective tariff.	15. Protective tariff.	15. No tariff.
16. No bounties.	16. Railroad and syndicate bounties.	16. No bounties.

Summary of Statistics for 1910 and 1911

Subjects.	Calendar years. 1910.	1911.
Production of iron ore, gross tons (1911 approximate)	56,889,734	43,550,633
Imports of iron ore, gross tons	2,591,031	1,811,732
Production of bituminous coal, gross tons	372,420,663	362,283,126
Production of Pennsylvania anthracite, gross tons	75,433,246	80,771,488
Production of all kinds of coal, gross tons	447,853,909	443,054,614
Shipments of Pennsylvania anthracite, gross tons	64,905,786	69,954,299
Imports of coal, gross tons	2,000,139	1,241,285
Domestic exports of coal, gross tons	13,805,866	17,432,753
Shipments of Connellsville coke, net tons	18,689,722	16,334,174
Production of coke, net tons	41,708,810	35,551,489
Production of pig iron, gross tons	27,303,567	23,649,547
Production of spiegeleisen and ferro-manganese, included in pig iron, gross tons	224,431	184,718
Production of Bessemer steel, gross tons	9,412,772	7,947,854
Production of open-hearth steel, gross tons	16,504,509	15,598,650
Production of crucible steel, gross tons	122,303	97,653
Production of electric and other steel, gross tons	55,335	31,949
Production of all kinds of steel, gross tons	26,094,919	23,676,106
Production of open-hearth steel castings, gross tons	863,351	571,191
Production of all kinds of steel castings, gross tons	940,832	646,627
Production of Bessemer steel rails, gross tons	1,884,442	1,053,420
Production of open-hearth steel rails, gross tons	1,751,359	1,676,923
Production of all kinds of rails, gross tons	3,636,031	2,822,790
Production of structural shapes, gross tons	2,266,890	1,912,367
Production of iron and steel wire rods, gross tons	2,241,830	2,450,453
Production of plates and sheets, except nail plate and skelp, gross tons	4,955,484	4,488,049
Production of nail plate, gross tons	45,294	48,522
Production of merchant bars, gross tons	3,785,731	3,047,362
Production of skelp, etc., gross tons	1,828,194	1,980,673
Production of all other rolled forms, gross tons	2,861,825	2,288,955
Production of all rolled iron and steel, gross tons	21,621,279	19,039,171
Production of iron and steel cut nails and cut spikes, kegs of 100 pounds	1,005,233	967,636
Production of steel wire nails, kegs of 100 pounds	12,704,902	13,437,778

(*Continued on page 65*)

SUMMARY OF STATISTICS FOR 1910 AND 1911—CONCLUDED

SUBJECTS.	Calendar years. 1910	1911
Production of tin plates and terne plates, gross tons	722,770	783,960
Production of charcoal blooms, slabs, bars, etc., for sale or for consumption of makers, gross tons	75,974	64,616
Imports of iron and steel, foreign value	$ 38,907,119	$ 28,995,600
Exports of iron and steel, home value	$201,271,903	$249,656,411
Miles of steam railr'd in operation on Dec. 31	243,107	246,573
Miles of new steam railroad built	3,918	3,293
Tonnage of iron and steel vessels built, calendar year	299,460	163,805
Immigrants landed in the year ended Dec. 31	1,071,885	782,545

THE WORLD'S LEADING PIG IRON AND STEEL PRODUCERS

The following table contains the production of pig iron and steel, from 1900-1911, by the three great pig iron and steel-making countries. To show relative production, the figures given are all in 1,000 metric tons of 2,204 pounds each:

	Pig Iron.			Steel Ingots.		
Year.	U. S.	Germany.	G. B.	U. S.	Germany.	G. B.
1900	14,010	8,521	9,052	10,382	6,646	5,131
1901	16,132	7,880	7,886	13,689	6,394	5,096
1902	18,106	8,403	8,654	15,186	7,781	5,102
1903	18,297	10,086	8,952	14,757	8,802	5,115
1904	16,761	10,104	8,700	13,746	8,930	5,107
1905	23,360	10,988	9,746	20,354	10,067	5,984
1906	25,712	12,478	10,311	23,739	11,135	6,566
1907	26,194	13,046	10,083	23,773	12,063	6,627
1908	16,191	11,814	9,438	14,248	11,186	5,380
1909	26,208	12,918	9,819	24,338	12,050	5,882
1910	27,740	14,793	10,380	26,512	13,699	6,107
1911	24,028	15,534	9,874	24,055	15,019	.....

The World's Production of Coal, Coke, Iron Ore, Pig Iron and Steel in 1910

To show relative production, the figures are all in 1,000 metric tons.

Countries.	Coal, lignite, 1,000 metric tons.	Per cent.	Coke, 1,000 metric tons.	Per cent.	Iron ore, 1,000 metric tons.	Per cent.	Pig iron, 1,000 metric tons.	Per cent.	Steel, 1,000 metric tons.	Per cent.
United States..	454,630	39.2	38,418	43.3	57,800	39.0	27,740	41.7	26,512	45.6
Germany	221,976	19.2	23,600	26.5	28,710	19.4	14,793	22.3	13,699	23.5
Gt. Britain.....	264,505	22.9	12,116	13.5	15,470	10.8	10,380	15.6	6,107	10.5
Aus. - Hung'y..	49,000	4.2	2,156	2.4	4,666	3.1	2,010	3.4	2,155	3.7
France	37,862	3.3	2,272	2.6	14,500	9.8	4,001	6.0	3,390	5.9
Russia	24,572	2.1	2,678	3.1	5,638	3.8	3,040	4.5	2,350	4.1
Belgium	23,927	2.1	3,111	3.4	123	0.1	1,804	2.7	1,450	2.5
Japan	14,799	1.3	.....	...	51	...	.....	...	.....	...
China	14,591	1.2	.....	...	203	0.1	.....	...	.....	...
Canada	13,011	1.1	819	0.9	213	0.1	752	1.2	835	1.4
Australia	12,246	1.1	286	0.4	176	0.1	.....	...	.....	...
India	12,092	1.1	.....	...	56	...	.....	...	.....	...
Africa	6,538[1]	0.5	.....	...	1,065[2]	0.7	.....	...	.....	...
Spain	3,550	0.3	521	0.6	8,667	5.9	367	0.6	220	0.4
Holland	1,200	0.1	.....	...	.....	...	.....	...	.....	...
Italy	400	...	397	0.5	551	0.4	215	0.3	635	1.1
Sweden	302	...	.....	...	5,184	3.5	594	0.9	470	0.8
Norway	.....	...	.....	...	.....	...	.....	...	.....	...
Newfoundland .	.....	...	.....	...	1,127	0.7	.....	...	.....	...
Cuba	.....	...	.....	...	1,452	1.0	.....	...	.....	...
Greece	.....	...	.....	...	608	0.4	.....	...	.....	...
Other countries	4,000	0.3	2,500	2.8	1,591	1.1	525	0.8	315	0.5
Total 1,159,201		100	88,974	100	147,851	100	66,221	100	58,138	100

[1]Transvaal and Natal.
[2]Algeria.

World's Iron and Steel Production 1850 to 1910

Growth of the world's pig iron and steel production, 1850-1910.

	Pig Iron.			Steel.		
Year.	Production, in 1,000 metric tons.	Increase in 1,000 metric t'ns.	Per cent[1].	Production in 1,000 metric tons.	Increase, in 1,000 metric t'ns.	Per cent[1].
1850	4,401	.....	..	85	.....	..
1855	6,150	1,749	40	120	35	41
1860	7,400	1,250	20	200	80	66
1865	9,481	2,081	28	422	222	111
1870	12,146	2,665	28	683	261	60
1875	13,920	1,774	14	1,926	1,243	183
1880	18,331	4,411	32	4,235	2,309	120
1885	19,792	1,461	8	6,041	1,806	43
1890	27,627	7,835	40	11,881	5,840	97
1895	29,387	1,760	6	15,651	3,770	32
1900	41,032	11,645	40	28,734	13,083	84
1905	54,053	13,021	32	44,296	15,562	54
1910	66,321	12,268	23	58,138	13,842	31

[1]Indicates per cent of increase in tonnage from year previous.

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